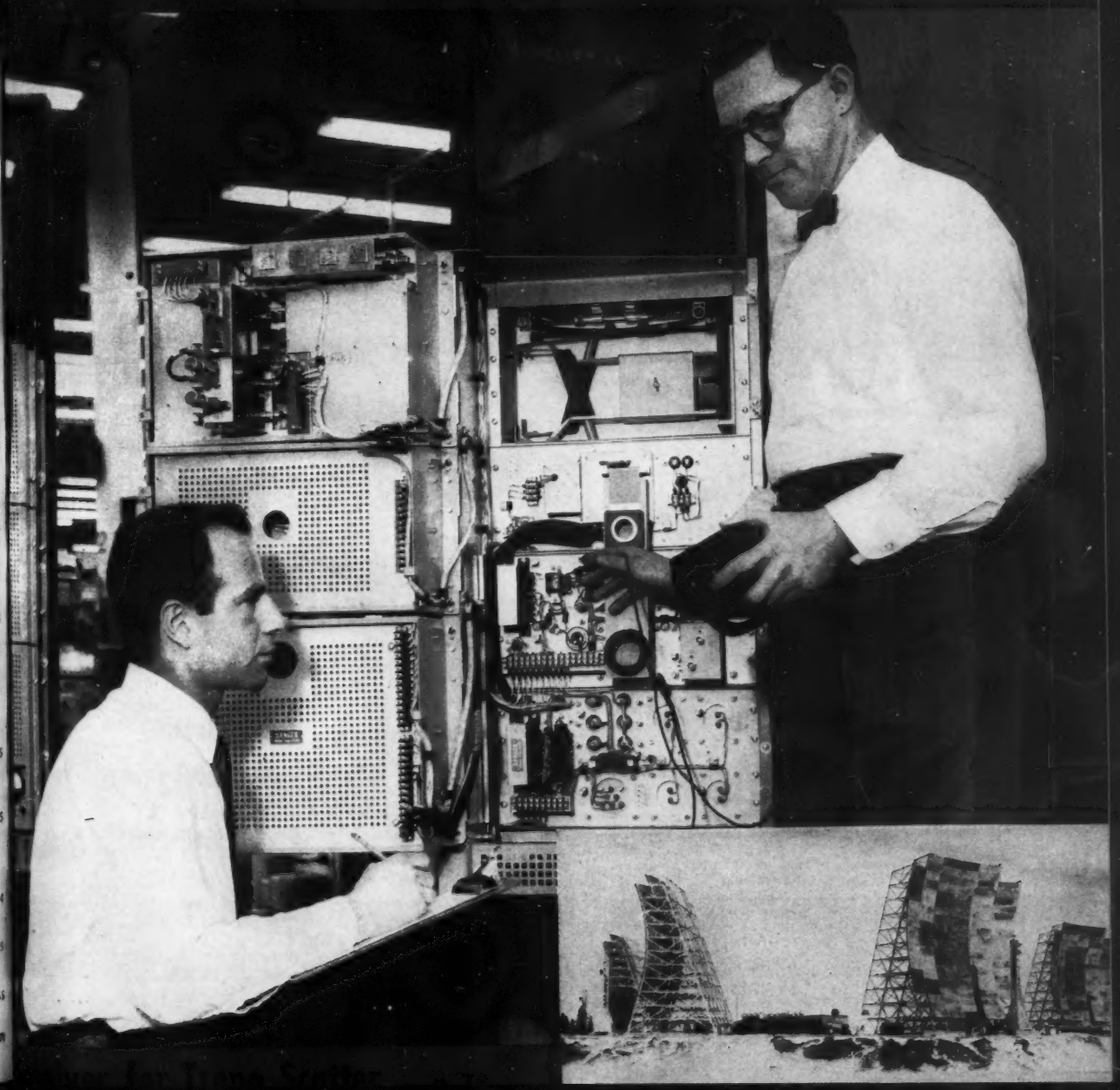
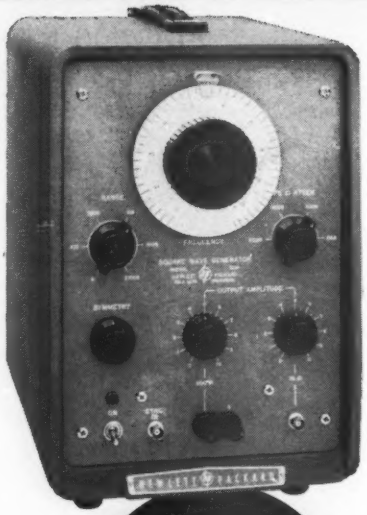
electronics

engineering edition



Doing Pulsed or "Fast" Circuit Work?

Square Wave Generator

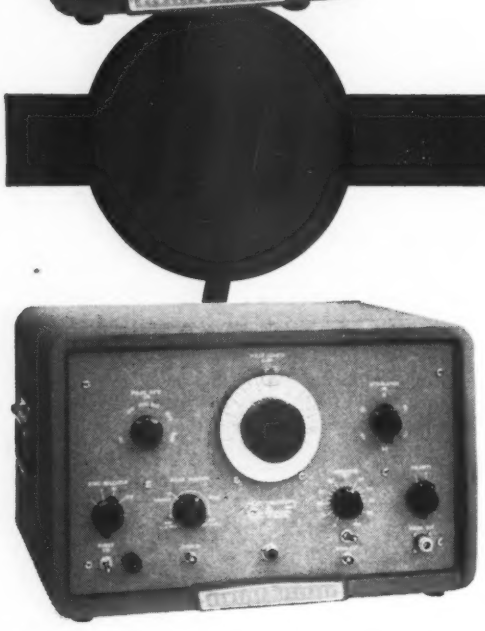


1 cps to 1 MC; 0.02 μsec rise time

-hp- 211A Square Wave Generator. Versatile, wide range instrument for testing oscilloscopes, networks, video and audio amplifier performance, modulating signal generators, measuring time constants. Offers simple control of electronic switchers; is also convenient for indicating phase shift, frequency response and transient effects.

Special features include two separate outputs — a 7 volt, 75 ohm circuit for television work and a 55 volt, 600 ohm output for high level work. Both outputs offer full amplitude variation. May be operated free-running or externally synchronized with positive going pulse or sine wave signal of 3 volts minimum amplitude. Compact, weighs only 25 lbs. Price $265.00.

Pulse Generator



0.07 to 10 μsec pulses, 0.02 μsec rise time

-hp- 212A Pulse Generator. Time saving basic instrument for radar, television and other "fast" circuit work, including testing rf amplifiers, filters, band pass circuits; oscilloscopes and peak measuring equipment, pulse modulating uhf signal generators. Offers positive or negative pulses of 50 watts amplitude, delay and advance sync out circuits for synchronizing to other circuits, direct-reading pulse length control, high quality pulses with 0.02 rise and decay, flat top and minimum overshoot. Jitter less than 0.01 μsec. Permits delivery of accurate pulses to end of long transmission lines; if line is correctly terminated, pulse shape is independent of line length, sync conditions, input voltage or output attenuator setting. Internal impedance 50 ohms or less, either polarity. Repetition rate, internal sync 50 to 5,000 pps, external sync 0 to 5,000 pps. Available for rack mount. Cabinet model $565.00.

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722-MD $225	0 to 1050 0 to 105	±0.1% or ±1$\mu\mu$f* ±0.1% or ±0.2$\mu\mu$f*	Capacitance Removed (for bridge substitution measurements)
722-ME $225	0 to 105 0 to 10.5	±0.1% or ±0.2$\mu\mu$f* ±0.1% or ±0.05$\mu\mu$f*	
722-N $210	100 to 1150	±0.1% or ±1$\mu\mu$f* *whichever is the greater	Total Capacitance (recommended for r-f use — lower metallic resistance and inductance)

Correction chart supplied permits greater accuracy — additional correction chart for residual eccentricity of worm drive furnished on special order.

FIXED CAPACITANCE STANDARDS

Type 1401 is an air-dielectric capacitor adjusted to ±(0.1% + 0.1$\mu\mu$f) accuracy.

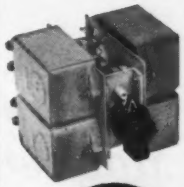
Type	Capacitance	Dissipation Factor	Price
1401-A	100$\mu\mu$f	<0.00004	$45
1401-B	200$\mu\mu$f	<0.00003	$46
1401-C	500$\mu\mu$f	<0.00002	$48
1401-D	1000$\mu\mu$f	<0.00001	$53

Type 1409 Standard Capacitor utilizes silvered mica and foil-stack construction. Units are aged to insure accuracy and stability. Dissipation factor is less than 0.0003 when measured at 1 kc and 23°C. May be used for either 2- or 3-terminal measurements.

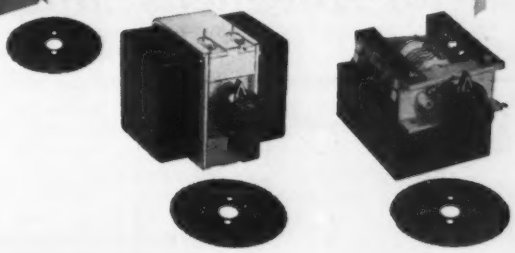
Type	Capacitance, μf	Price
1409-F	0.001	$32
1409-G	0.002	$32
1409-K	0.005	$34
1409-L	0.01	$34
1409-M	0.02	$36
1409-R	0.05	$39
1409-T	0.1	$42
1409-U	0.2	$50
1409-X	0.5	$80
1409-Y	1.0	$130

DECADE CAPACITORS

Type 980 Decade Capacitor Unit is an assembly of high-quality capacitors mounted on an eleven-point switch to give a total capacitance variation of 10:1 in ten equal increments. All increments are accurate to within ±1% except the Type 980-L which is within ±2%, and the Types 980-F, -G, and -H, which are ±0.5% units. Zero capacitance of all units is 10$\mu\mu$f.



Type	Capacitance	Dielectric	Dissipation Factor at 1 kc and 23°C	Price
980-A	1.0μf in 0.1μf steps	Polystyrene	<0.0003	$66
980-B	0.1μf in 0.01μf steps	Polystyrene	<0.0003	51
980-C	0.01μf in 0.001μf steps	Polystyrene	<0.0003	57
980-F	1.0μf in 0.1μf steps	Mica	<0.0005	132
980-G	0.1μf in 0.01μf steps	Mica	<0.0005	60
980-H	0.01μf in 0.001μf steps	Mica	<0.0005	45
980-L	1.0μf in 0.1μf steps	Paper	<0.010	36
980-M	0.1μf in 0.01μf steps	Molded Mica	<0.001	42
980-N	0.01μf in 0.001μf steps	Molded Mica	<0.001	32



DECADE BOXES are assemblies of Type 980 units, and are available in a variety of dielectrics to meet the needs of either general purpose or critical measurements. All units are 1.110μf maximum in steps of 0.001μf.

Type	Type 980 Decades used	Dielectric	Remarks	Price
1419-A	A, B, C	Polystyrene	for 2- or 3-terminal measurements	$205
1419-K	F, G, H	Mica		270
219-M	L, M, N	Paper & Molded Mica	2-Terminal Only	135

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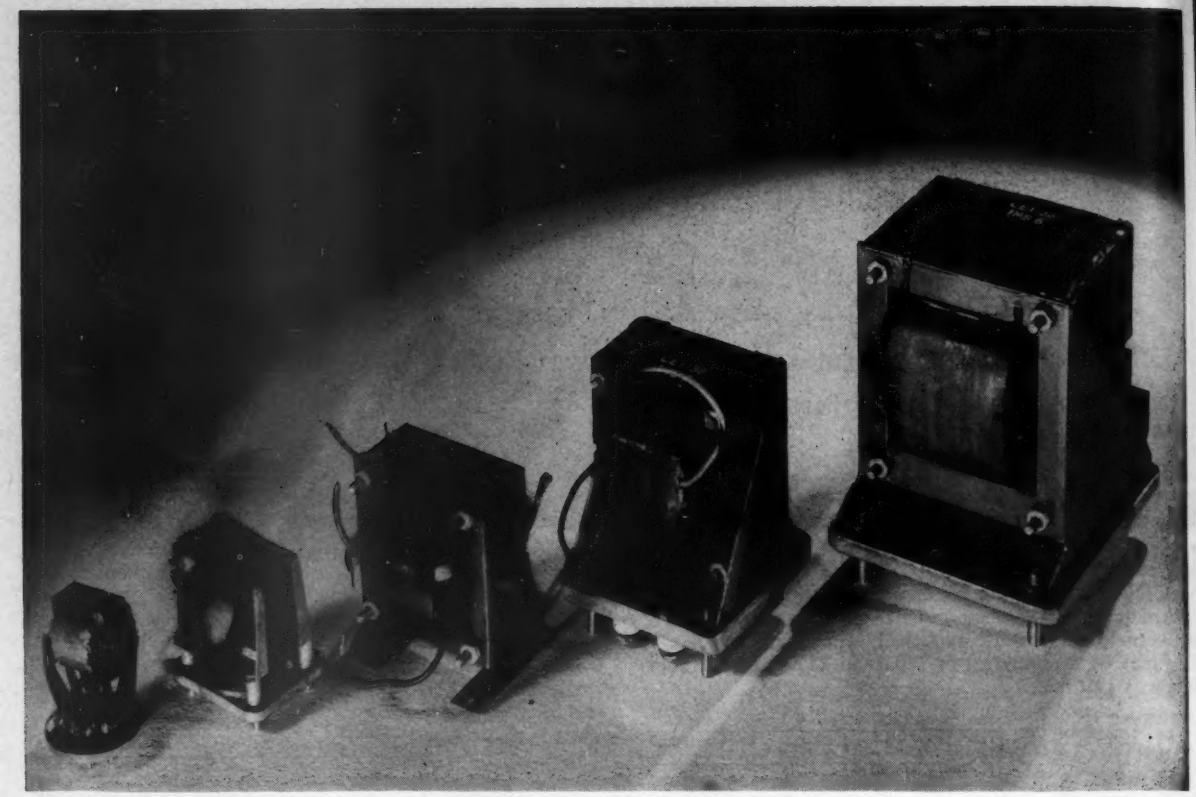

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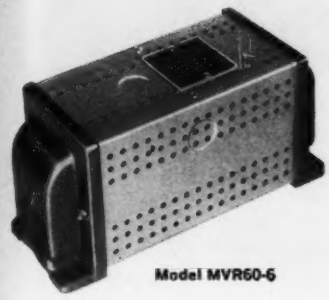
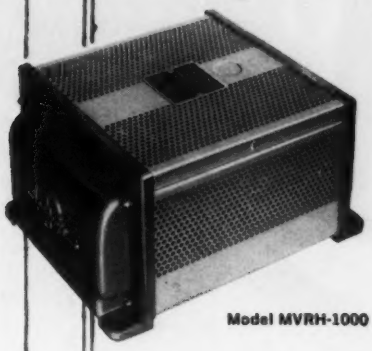


Model MVR60-6



Model MVRH-1000

Model MVR30

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Weight: 5 lbs.

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Model MVRH-1000
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TYPICAL CHARACTERISTICS

TYPE	DESCRIPTION	Vibration Output* (maximum) mVac	Vibration Output** peak to peak mv	Heater Volts	Heater mA	Plate Volts	Plate mA	Cathode Bias Resistor ohms	Screen Volts	Screen mA	Amplification Factor	Mutual Conductance μmhos
CK5702WB	Video Amplifier, Pentode	50	240	6.3	200	120	7.5	200	120	2.6	—	5000
CK5703WB	High Frequency Triode	10	50	6.3	200	120	9.4	220	—	—	25.5	5000
CK5704WA	High Frequency Diode	—	25	6.3	150	Max. inverse peak = 460 volts; max. I_o = 10 mA						
CK5744WB	High Mu Triode	15	75	6.3	200	250	4.2	500	—	—	70	4000
CK5783WB	Voltage Reference	20	—	Operating voltage approximately 85 volts between 1.5 and 3.5 mA								
CK5784WB	RF Mixer Pentode	75	300	6.3	200	120	5.5	230	120	4.1	—	3200
CK5787WB	Voltage Regulator	20	—	Operating voltage approximately 98 volts between 5 and 25 mA								
CK6247WA	Low Microphonic	2.5	25	6.3	200	250	4.2	500	—	—	60	2650
CK6533WA	Low Microphonic Triode	1.0	15	6.3	200	120	0.9	1500	—	—	54	1750

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*15g, 40 cps, fixed frequency
**15g, 30 to 1000 cps sweep

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BUSINESS BRIEFS

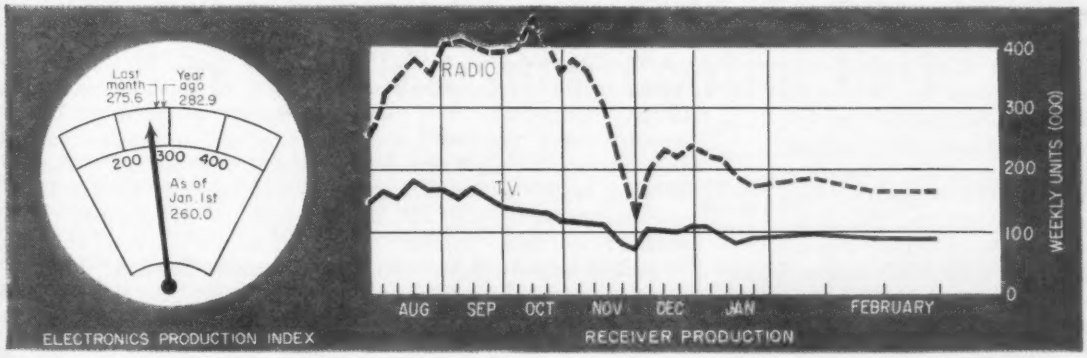
ELECTRONICS NEWSLETTER

COMPATIBLE STEREO DISK, described and demonstrated by Columbia Records in a last-minute switch in program at an IRE technical session, has raised eyebrows in the phonograph record and hi-fi component industries. New system, which Columbia is expected to promote this spring in a full line of stereo disks and home instrument packages, uses vertical-lateral groove modulation, but with sum-and-difference signals rather than split channels. Sum signal comprises the lateral component, while the difference is engraved vertically. System permits both stereophonic and monaural sound to be put on one disk, is thus compatible with existing monaural equipment.

MARKET OUTLOOK for semiconductor devices and printed circuitry is brighter than ever, it's believed by many in our industry. Rectifiers, both germanium and silicon, plus small signal diodes will top sales of $100 million by 1960, says one firm. Another prediction: Silicon power rectifiers for commercial and consumer products alone will rise to $25-$35 million in two years as the result of mass production and unit prices as low as 40¢, says General Instrument Corp. Printed circuitry will show a 500 percent increase over 1957 by 1961, according to market researchers of Formica Corp., subsidiary of American Cyanamid Corp. They say use in military electronics will jump from 4.4 percent in 1957 to 28.2 percent in 1961, and that markets will open in the air conditioning and appliance industries.

LOW-PRICED JAPANESE RADIOS and components, appearing in greater numbers than ever this year on the U. S. market, are bothering some segments of the industry. Electronic Industries Association has appointed a committee to investigate possible avenues of relief. Problem: More than 600,000 Japanese radios are believed to have been imported last year, with the present rate estimated at 100-150,000 a month, many of them transistor radios. Japan's labor differential often means a Japanese set can sell for less than what it costs an American manufacturer to make, efficiency notwithstanding. Other Japanese items arriving in increased quantities: receiving tubes, sound equipment, resistors, capacitors and loudspeakers. (See p 16.)

LATEST MASER amplification device developed by Columbia University and Naval Research Laboratory may permit probing of the outer edge of the universe through NRL's 50-ft radiotelescope. Maser's synthetic ruby heart is sensitive to signals from planets or galaxies at a frequency of 9,000 mc. It reacts by emitting some of its own energy at the same frequency, thus amplifying the waves. This principle of amplification may give maser-mounted radiotelescopes as much as 100 times the sensitivity of present nonmaser electronic types. Model now being tested at NRL will first examine radio waves from Venus. Ultimately, a maser-telescope may not only give detailed information about known objects, but also extend the radiotelescope's range far beyond farthest known galaxies.



FIGURES OF THE WEEK

RECEIVER PRODUCTION

(Source: EIA)	Mar. 21, '58	Mar. 14, '58	Mar. 22, '57
Television sets, total	91,416	88,598	111,601
Radio sets, total	170,655	170,434	299,075
Auto sets	40,218	41,942	104,385

STOCK PRICE AVERAGES

(Source: Standard & Poor's)	Mar. 26, '58	Mar. 19, '58	Mar. 27, '57
Radio-tv & electronics	46.50	45.82	47.90
Radio broadcasters	58.52	59.51	62.99

FIGURES OF THE YEAR

Totals for first month

	1958	1957	Percent Change
Receiving tube sales	26,805,000	37,571,000	− 28.6
Transistor production	2,955,247	1,436,000	+105.8
Cathode-ray tube sales	621,910	760,860	− 18.3
Television set production	433,983	450,190	− 3.6
Radio set production	1,026,527	1,085,529	− 5.4
TV set sales	581,486	623,359	− 6.7
Radio set sales (excl. auto)	534,640	563,363	− 5.1

Analyzing words written centuries ago (left) and studying chemicals with 10 constituents are just two . . .

New Jobs For Computers

They're being used for literature abstracting, spectroanalysis and restoring documents

DIGITAL COMPUTERS are now doing three new jobs—literature abstracting, spectroanalysis of chemicals and restoration of missing words in ancient documents.

Details were released recently during the IRE convention.

In the literature abstracter, the information content of each sentence in an article is compared and graded. Experimental abstracts were prepared by key punching every word on cards, transcribing card records onto magnetic tape and performing necessary data processing on an IBM 704.

The computer is programmed to read tape text, separate individual words, note position of words in sentences and record punctuation before or after each word.

Words are then alphabetized, occurrence count of each word made, words of stipulated low frequency deleted and the remaining words sorted in order of text position. Significant words and total words per cluster are then determined and the significance of each sentence calculated. H. P. Luhn of IBM's Yorktown Heights Research Center reported this progress.

A computer technique to analyze a chemical with 10 constituents was announced by Federal Telecommunications Labs. Entire mixture spectrum is used for analysis to increase accuracy and resolving power of spectroanalyzer.

Spectral information is converted to numerical form by analog-to-digital techniques and punched onto paper tape.

Each spectra in a library of infrared absorptions of basic constituents is compared to unknown mixture by multiplying numerical information in the library by that contained on the specimen tapes, adding the products at each wavelength, substituting these values into a series of linear simultaneous equations as coefficients and solving the equations.

In document restoration, a computer analyzes words preceding and following each gap, and takes in account size of gap and possible number of characters it contained, reported P. Tasman of IBM World Trade. He said computers have been used to make a qualified guess as to what words were originally written in hundreds of mutilated sections of the Dead Sea Scrolls.

After analysis step, scrolls were scanned electronically until the computer found one word that fitted into context. Initially, 30,000 words contained in scrolls were punched on separate cards and information was then converted to two reels of magnetic tape.

X-Rays Measure Fruit Freezing

POTENTIALLY PRACTICAL method for detecting frost damage in citrus fruit is in experimental use at the University of California, Los Angeles.

X-rays are beamed through fruit rotating on a platform. Resistance to the X-rays is measured as a voltage, which increases in proportion to the non-uniformity of the fruit. Non-uniformity of fruit sections indicates frost damage.

The machine was designed by William T. Kyle, who heads the university's Central Electronics Facility, and Joseph E. McAteer. Kyle thinks a commercial model handling 10 units of fruit a sec would cost $10,000 to $20,000.

Speed of the prototype is three or four units of fruit a min. A commercial model would include devices for channeling the fruit into the detector and for rejecting bad fruit.

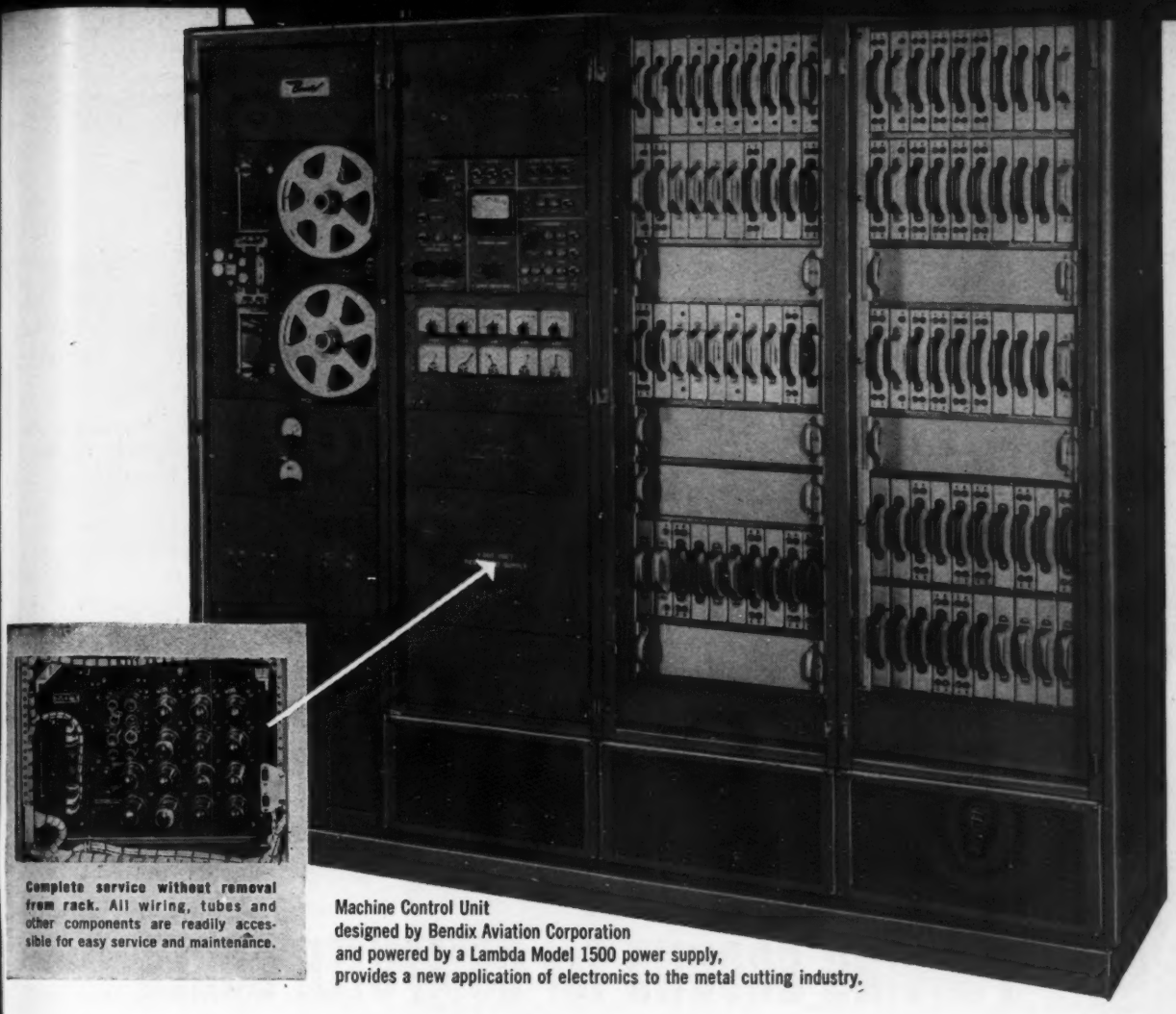
Moon Shot On the Way?

NOW THAT Explorer III has joined Explorer I, Vanguard and Sputnik II in the heavens, the air is full of judgements and prophecies as to where man goes from here in the exploration of space. Whatever happens, electronics stands to get bigger and more challenging assignments.

Last week in Chicago, Vice President Nixon told ELECTRONICS that the world is learning more from our satellites than from the Russians' because of better instrumentation. Referring to a possible "moon shot", he said the objec would be scientific not military although we might get better information on weather and outer-space environment. The Vice President urged that the U. S. go ahead in its scientific research, not on a crash basis but on one adequately financed.

In Los Angeles, Lee Du Bridge, president of Cal-Tech called man the least useful and most expensive item that could be put aboard a satellite. He described as a ridiculously expensive luxury the equipment needed to keep a man alive in a satellite and get him down again when instruments can gather information more accurately.

Also in L. A., Wernher Von Braun, the Army's missile expert, asserted that the Defense Dept.'s



Complete service without removal from rack. All wiring, tubes and other components are readily accessible for easy service and maintenance.

Machine Control Unit
designed by Bendix Aviation Corporation
and powered by a Lambda Model 1500 power supply,
provides a new application of electronics to the metal cutting industry.

Stock unit with panel modifications

Bendix Aviation uses Lambda Power Supplies in New Machine Control Unit

Bendix Aviation engineers chose standard Lambda power supplies as the voltage source for this new control unit. Employing computer type circuits, the apparatus directs the operation of a milling machine from numerical data recorded on punched tape.

Dependable Lambda power supplies are specified for more industrial, research, and military applications than the ten next-most-popular makes combined. When you select Lambda power supplies, you do so with the assurance that your judgment is supported by the overwhelming vote of all engineers who are concerned with power supply specifications. And Lambda power supplies are available for immediate delivery from stock.

Send for the Lambda catalog. It includes America's most widely used rack, bench and portable models, for all needs through 1.5 amperes.

NEW COM-PAK® POWER SUPPLIES SAVE VALUABLE PANEL SPACE
Models through 1.5 amperes
Three voltage ranges: 0-200, 125-325, 325-525 VDC

C-200 series–	200 MA–5¼"	panel height–from	$159.50
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C-1500 series–	1500 MA–8¾"	panel height–from	550.00

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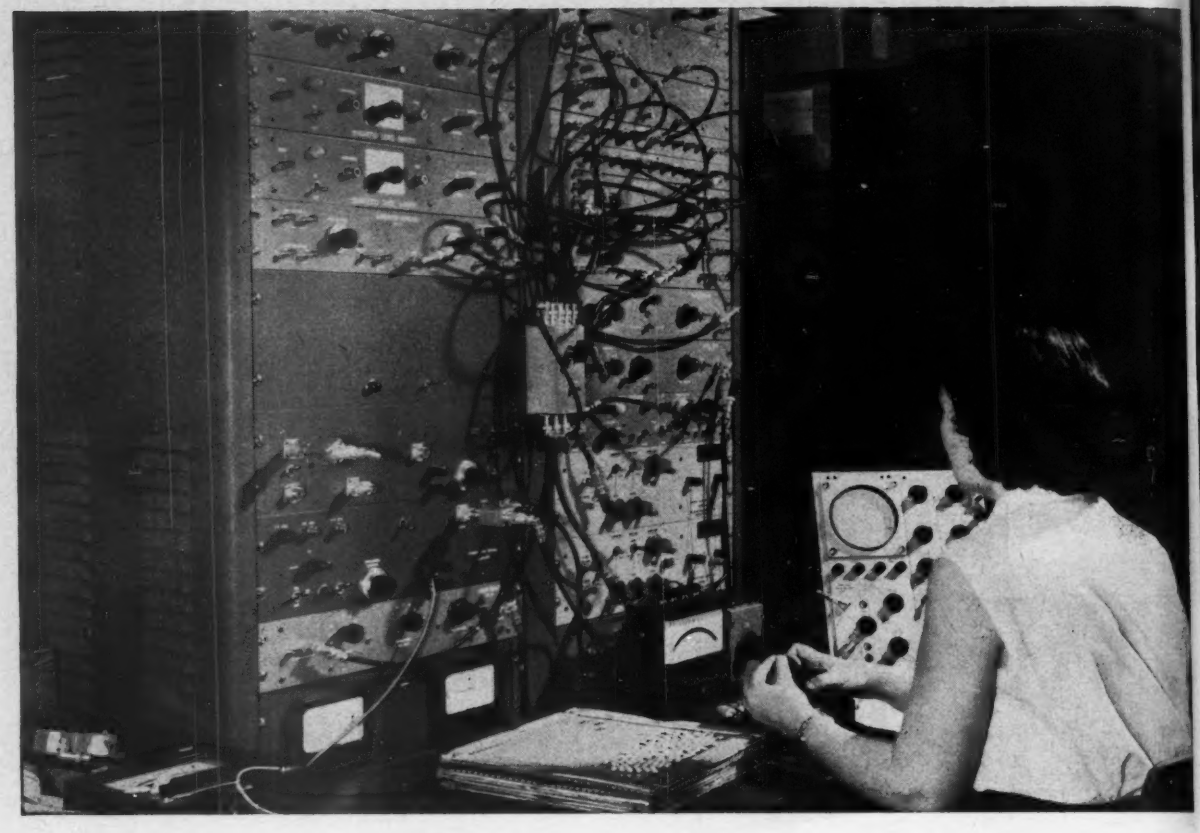
CIRCLE 5 READERS SERVICE CARD



PROVING GROUND for COMPUTER CORES

Take the hundreds of tiny Arnold tape wound bobbin cores that are the heart of some of today's remarkable computing machines.

Each one must provide reliable, uniform performance. Each must meet rigid standards of magnetic and physical specifications. And, most important of all, their basic material properties must be examined for proper grading of cores to assure performance of the final product.

Only precision manufacture can assure you this top-quality performance in magnetic core materials . . . and at Arnold *each* core is made and painstakingly checked before shipment by the latest, most thorough methods and equipment.

Some of this testing equipment and many of our production methods were developed by us—for our own use exclusively—and surpass the standards set by the industry. You *know*, when you use Arnold cores, that the materials you receive have met all the rigid standard tolerances, plus any individual specifications you may have.

● Let us supply your requirements for Bobbin Cores—or other tape wound cores, powder cores, permanent magnets, etc.—from the most complete line of magnetic materials in the industry. *And remember, Arnold products are precision-made, precision-tested, to your specifications.*

WSW 7047

Write for these Technical Booklets

Bulletin TC-108A

"TAPE-WOUND BOBBIN CORES FOR COMPUTER APPLICATIONS"

Includes essential data on applications and properties, fabrication and testing of Arnold Bobbin Cores; lists standard sizes, etc.

Bulletin GC-106C

"ARNOLD MAGNETIC MATERIALS"

Contains data on the complete Arnold line, including cast and sintered Alnico magnets, Silectron cores, tape-wound cores, bobbin cores, Mo-Permalloy and iron powder cores, and special permanent magnet materials.

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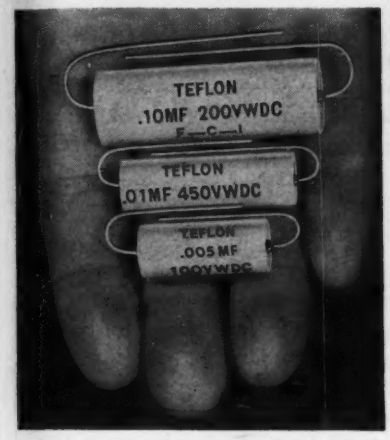
DU PONT

TEFLON®
FLUOROCARBON RESINS

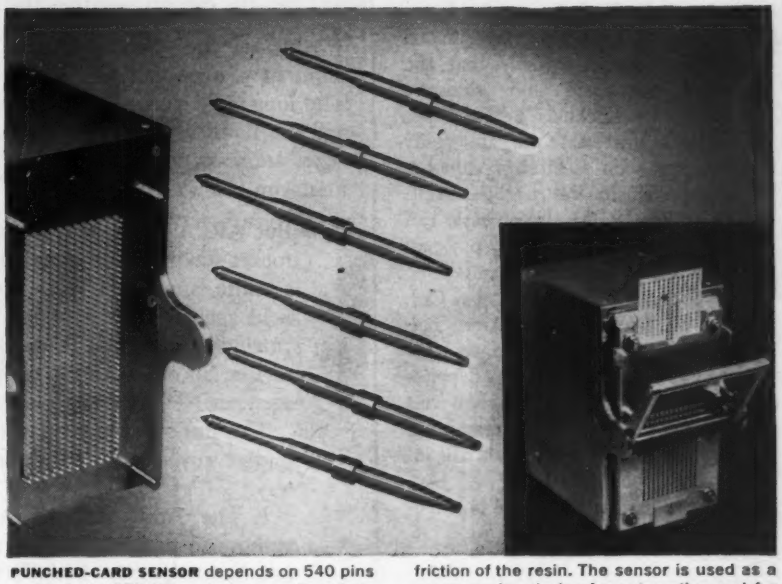
ELECTRONIC DESIGN NEWS

Low friction of TFE resin insures smooth action of punched-card sensor



Stable capacitors for missiles have high thermal,electrical ratings

CAPACITORS made of TFE-fluorocarbon resins possess outstanding stability, very low temperature coefficient, and excellent insulation resistance at high temperatures. In designing these capacitors, only bonded mica, ceramic dielectrics and TFE resins were found to meet the temperature specifications. Of these three, the TFE resins were selected as having greatly superior electrical characteristics. The capacitors are rated up to 200°C. The dielectric constant and very high sensitivity of the TFE resins remain virtually unchanged over the broadest operating ranges of frequency and temperature. The dissipation factor of the dielectric is less than 0.0003. (Manufactured by Film Capacitors, Inc., New York, New York.)



PUNCHED-CARD SENSOR depends on 540 pins molded of a TEFLON resin for smooth switching operation. The pins slide easily into the holes, because of the extremely low surface friction of the resin. The sensor is used as a programming device for automation and for multiple switching. (Manufactured by Metron Corporation, Lambertville, New Jersey.)

At the heart of this switching device are 540 pins made of a TFE-fluorocarbon resin, which translate the message on a punched card by activating complex electrical circuits. Each of the 540 positions (arranged 12 wide by 45 high) has a corresponding spring-loaded pin and a normally closed single-pole single-throw switch. The card is pressed forward onto the pins by a handle. Where there is a hole in the card, the pin slides through practically without friction. Where there is no hole, the sturdy pin is pushed forward by the card and opens a switch. Trouble-free operation of this complex sensing device is dependent on the properties of TFE-fluorocarbon resins.

TFE-fluorocarbon resins are considered almost perfect electrical insulators. Their dielectric strength ranges from 400 to 4,000 volts per mil, depending on thickness. They have virtually no moisture absorption, and retain their dimensional stability under all conditions of humidity. No other structural material has so low a coefficient of friction. TFE resins are rated for operation from close to absolute zero to 250°C. They can be molded to close dimensions and machined to tolerances of half a mil.

The properties of TFE resins might well be important in your next product. For more facts on Du Pont TEFLON TFE-fluorocarbon resins, including technical data and applications, write to: E. I. du Pont de Nemours & Co. (Inc.), Polychemicals Dept., Room 174 Du Pont Building, Wilmington 98, Delaware. In Canada: Du Pont Company of Canada (1956) Limited, P. O. Box 660, Montreal, Quebec.

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TEFLON is Du Pont's registered trademark for its fluorocarbon resins, including TFE (tetrafluoroethylene) resins discussed herein.

weapons-systems concept is impractical in the space age. It has, he said, caused us serious delays due to an inflexible set of paper requirements designed to fill an immediate military need.

Courtland Gross, president of Lockheed, lauded the government's plan of assigning prime roles to aircraft firms, stated that southern California firms are involved in 25 of the nation's present 43 missile projects.

Lt. Gen. C. S. Irvine, Air Force deputy chief of staff, announced in Los Angeles recently that the rocket assemblies and guidance systems for Lockheed's Pied Piper reconnaissance satellite are ready to fire as soon as finishing touches are applied to the satellite itself. The Thor IRBM, Irvine says, can lift a one-ton satellite payload; Atlas ICBM can lift two tons.

Speaking in New York, Lt. Col. Guy H. Drewry of the Army Ballistic Missile Agency said that 95 percent of the battle for a dependable inertial guidance system has been won. Some of the remaining product improvement work will involve use of printed circuits, electronic switching to replace mechanical devices.

Tanker Plane Market Grows

TODAY MORE transport and tanker planes are being made, all are using more electronic gear.

Here are facts on this expanding market:

C-130B: Lockheed's 4-prop jet missile-carrying transport recently got a $22 million letter contract. Total estimated will hit $100 million for 53 planes. Production is assured to 1960.

Electronics is mostly government furnished. Lockheed estimates each plant to carry $100,000 worth of electronic equipment. Besides ordinary aircraft communications and navigational electronic equipment, the C-130B carries Doppler radar, loran and Tacan.

KC-135A: Boeing's jet Strato-

WASHINGTON OUTLOOK

AFTER WEEKS of bureaucratic pulling and hauling over policy, the Advanced Research Projects Agency, the Defense Dept.'s new space organization, has decided to do its business by three different methods:

1. Through conventional transfer of funds to one of the three military departments, which in turn will channel money and contract authority to their contracting agencies in the field.

2. By directly placing work orders on the military field agencies, bypassing established Pentagon lines of authority.

3. By direct contracts with private companies, research facilities and educational institutions. ARPA officials, however, stress this method will be "the exception rather than the rule."

Whether the space project is a continuing, long-term program or more of a one-shot project will determine how it will be handled. The long-range antimissile missile project, now assigned to the Army, and the Ballistic Missile Early Warning System, under the Air Force's aegis, are being administered by the first method—through the regular Pentagon chain of command.

● **But ARPA's first new project,** calling for four and possibly five rocket shoots to the moon and two and possibly three more earth satellite launchings, will be run on direct work orders to military field agencies. The project's objective is to expedite action by cutting through the Pentagon's varied echelons of administrative review, allowing ARPA to issue direct orders to the contracting agencies.

The project—which may run to over $100 million (the initial budget covers only $8 million until June 30)—breaks down this way:

1. The Army Ballistic Missile Agency, Huntsville, Ala., is authorized to use modified Jupiter-C rockets for one and possibly two "lunar probes" and three more Explorer earth satellites, has received $5 million to get the work under way. It's unlikely that ABMA will bring in any new contractors.

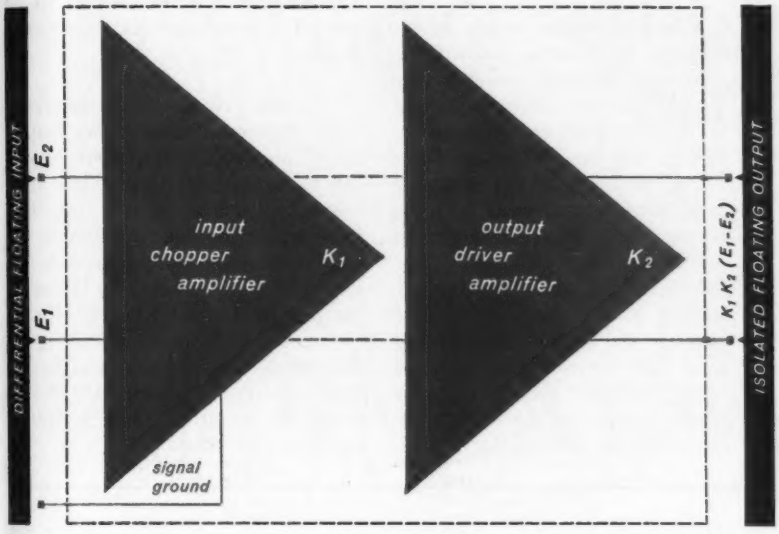
2. The Air Force ballistic missile division of ARDC, Los Angeles, has been initially allocated $3 million for three lunar probes. The launching vehicle will consist of the Douglas-North American Aviation Thor IRBM as the first stage, the Navy Vanguard's Aerojet-General second-stage motor as the second stage and a third stage yet to be selected but most likely a solid-propellant engine.

Guidance and control system will presumably include Minneapolis-Honeywell's three-axis gyro reference and Sperry Rand's magnetic-amplifier autopilot and servo system developed for Vanguard.

Negotiations are under way for contractors to assemble the launching vehicle, produce parts of the lunar payload, and develop more advance guidance gear.

3. The Naval Ordnance Test Station, Inyokern, Calif., which developed the Navy's Sidewinder infrared air-to-air missile, has been initially allocated $200,000 to develop a "mechanical ground scanning device"—a simple instrument to be carried in the moon probe vehicle (which will not contain a regular tv camera). NOTS is unlikely to contract much if any of its project to private firms.

New! KIN TEL's true differential DC amplifier...

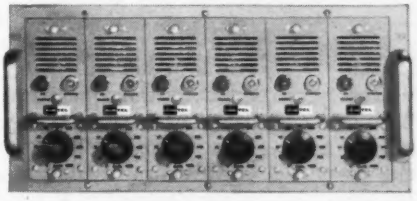


completely isolates input from output!

AMPLIFY MICROVOLT-LEVEL DATA SIGNALS New transistorized differential DC amplifiers provide extremely high common-mode rejection, very low drift, high output capability, and excellent stability and linearity... all unaffected by load or gain changes. Ideal for thermocouple amplification, they eliminate ground loop problems; allow the use of a common transducer power supply; permit longer cable runs; drive grounded, ungrounded or balanced loads, and can be used inverting or non-inverting. The 114A is the *perfect instrumentation amplifier.*

BRIEF SPECIFICATIONS – 114A DIFFERENTIAL DC AMPLIFIER

- 120 db common-mode rejection from DC to 60 cps.
- Gain of 10 to 1000 in 5 steps, continuous variation between steps.
- Gain accuracy 1.0% DC 10 cps, 3% to 30 cps, 3 db down at 120 cps.
- DC gain stability and linearity 0.1%.
- <5 μv noise; <5 μv drift at gain of 100 or above.
- Maximum output capability 10V at 10 MA.
- 100 K ohm input, <1 ohm output Z (min. load res. 20 ohms, max. load cap. 1.0 μf).



Six KIN TEL amplifiers in compact 19" rack mountable module.

STANDARD WIDEBAND DC AMPLIFIERS can be used single-ended or for floating input applications. An operational version permits the user to employ his own feedback networks to limit bandwidth, generate transfer functions, obtain specific gains and perform integrations. Specifications for the 111 series, Wideband DC Amplifiers include: <2 μv drift; <5 μv noise. ±35 V, ±40 MA output. 100 K ohm input, 1 ohm output Z; 1.0 μf allowable output cable capacity. 0 to 1000 gain in ten steps, with continuous 1 to 2 times variation of each step. Gain accuracy (freq. response) ±1.0% DC to 2 KC, <3 db down at 40 KC.

ALL KIN TEL DC AMPLIFIERS feature integral power supplies, convenient plug-in mounting and KIN TEL's proven chopper feedback amplifier circuitry for unsurpassed stability, accuracy and reliability. They have accumulated over 500 years of operating time, and in one installation alone have logged over a million hours of trouble-free operation. Records like this are the result of stringent quality controls, thorough testing and calibration, and years of experience in the design and manufacture of thousands of chopper stabilized DC amplifiers.

FOR GREATER ACCURACY, SIMPLICITY, RELIABILITY, and the elimination of carrier system balance problems, replace complex carrier systems with a KIN TEL packaged "plug-in" DC instrumentation system – complete from input transducer to output device.

Over 10,000 KIN TEL instruments in use today!

Representatives in all major cities.
Write today for demonstration or literature.
5725 Kearny Villa Road, San Diego 11, California, Phone: BRowning 7-6700.

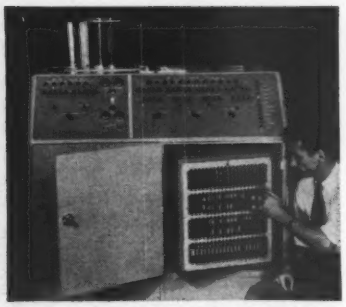
KIN TEL

A Division of Cohu Electronics Inc.

tanker is used for inflight refueling. Gen. LeMay once said he needed two KC-135's for every three B-52's. GPL's Doppler radar, APN-81, is used.

C-133A: Douglas' 4-turboprop air missile carrier is capable of carrying IRBM's and ICBM's.

C-123B: Fairchild's twin-engine piston-powered transport is designed for assault landings to deliver troops and take out casualties. It was also tested successfully for delivering paratroopers. Besides standard electronic equipment, most of which is government furnished, some planes are equipped with loran. Total contract for 303 planes will be completed in July.



This transistorized route reference computer is busy as . . .

Canadians Test Electronic Sorter

AN ELECTRONIC MAILMAN, now in training at the post office in Ottawa, Canada, is doing quite well. His only fulltime human helper will be a girl who will code backs of envelopes with special data to give routing information.

The automatic postal system was described in detail recently at the national IRE convention by Maurice Levy, technical advisor to the Canadian Post Office, and his associates, A. Baraszcewski and K. H. Ullyatt.

Levy estimated that automation equipment of this kind for large cities would probably cost about a half million dollars.

The electronic post, simplest devised so far, is suitable for cities with populations of 100,000 or over. Fluorescent ink is used for the printed code.

MILITARY ELECTRONICS

• **Airborne electronic** countermeasures system is being prime contracted for BuAer by Sanders Associates.

• **Army's decision** to give private industry the Pershing job will immediately expand private contractor business. Future implications of the trend are even greater. Martin will be in charge of the entire project: R&D, reliability testing and production of both the missile and associated ground equipment.

Martin will also furnish engineering, maintenance, training and field service. The development program will be supervised by the Army Ballistic Missile Agency which is under the new Army Ordnance Missile Command headed, as of March 31, by Maj. Gen. John B. Medaris.

• **New production contract** amounting to $75 million for Sparrow III is awarded to Raytheon by BuAer.

• **White Alice,** tropsospheric scatter communication system that covers most of Alaska, went into full operation on March 26. It was Prime contracted at a cost of $140 million by Western Electric. Operation and maintenance is being carried out under Air Force contract by Federal Electric. Entire system includes 32 station installations, covers approximately 3,100 route mi., provides 171,000 telephone circuit mi. and 50,000 teletypewriter circuit mi.

Thermonuclear Propulsion Eyed

SCIENTISTS were this week mulling the possibilities of a thermonuclear propulsion system.

Space flight looms large as possibly the first appropriate application of controlled fusion reaction, said Milton Clauser of Ramo-Wooldridge's Space Technology Laboratory. "Just as the turbojet engine was the first appropriate application of the gas turbine."

One key factor is direct power conversion by fusion, Clauser told a Boston conference on Extremely High Temperatures. The director of R-W's Physical Research Laboratory outlined fundamental requirements and limitations of magneto hydrodynamic propulsion, with emphasis on the exploration of the possibilities of thermonuclear propulsion.

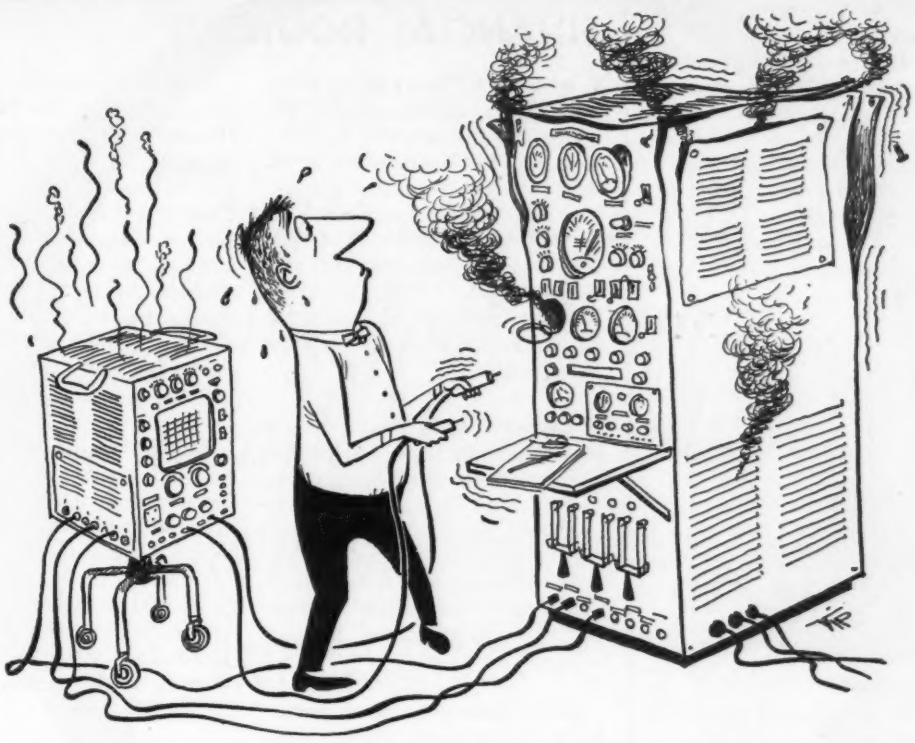
Possibilities of space flight applications in magnetohydrodynamics were cited by G. Sargent Janes and Richard M. Patrick of Avco in their paper on "Production of High Temperature Gas by Magnetic Acceleration" (ELECTRONICS, Jan. 24, p 17.)

More than 500 American and European scientists took part in the two-day parley sponsored by Air Force Cambridge Research Center for discussion of physical phenomena in the range beyond 50,000 K. "The ultimate goal, of course," said the chairman, "is the temperature region favorable for thermonuclear reaction."

Papers told of experimental work on electric arcs; inductive energy storage as a tool for high temperature research; a microwave thermometer for millions of degrees; plasma motors; spectroscopic temperature determinations; and behavior of materials subjected to ultrahigh temperature environments.

The Army Engineers R&D Laboratory at Fort Belvoir took advantage of the gathering to spread the word that they are looking for a new light source. "WANTED by the U. S. Army," said a notice. "A light source which: 1. Is larger than 100 square millimeters; 2. Is brighter than 10,000 candles per square millimeter; 3. Can be projected by a 30-60 inch reflector to make a searchlight; 4. Together

How to Save Man Days in Research and Testing Involving Transients—**No. 6** *of a series*



PROBLEM: Transient Analysis—Economy in Testing Procedures

Using conventional oscilloscopes, careful analysis and study of nonrecurrent wave forms in complex and costly electronic equipment involves any number of tests and retests. While ferreting out spurious signals—caused by malfunctioning components, loose connections, pigtails of solder or other circuit troublemakers—fatigue and taxed patience result in a **waste of** both **time** and **money.**

SOLUTION: The Hughes MEMO-SCOPE® oscilloscope holds transient wave forms in place until they are intentionally erased. There is no more need for repetitious testing which oftentimes damages costly electronic equipment. A **storage type oscilloscope,** it allows careful study and analysis of wave forms until all desired information is obtained.

HUGHES MEMO-SCOPE OSCILLOSCOPE

STORAGE TUBE—5-inch diameter Memotron® Direct Display Cathode Ray Storage Tube. Writing speed for storage: 125,000 inches per second. The optional Speed Enhancement Feature multiplies writing speed approximately four times. Plug-in type preamplifiers for greater flexibility are available as optional equipment.

APPLICATIONS—Presentation of tube or transistor characteristics without the necessity for repetition. Displaying frequency response curves with single scan through the desired spectrum. Investigation of transient behavior for power supply regulation. Transients encountered in ballistic or missile firing. Impact testing.

Arrange to see this "oscilloscope with a memory" in action. A Hughes representative in your area will set up a demonstration in your company at your convenience. For demonstration write:

HUGHES PRODUCTS MEMO-SCOPE Oscilloscope
International Airport Station, Los Angeles 45, California

Creating a new world with ELECTRONICS

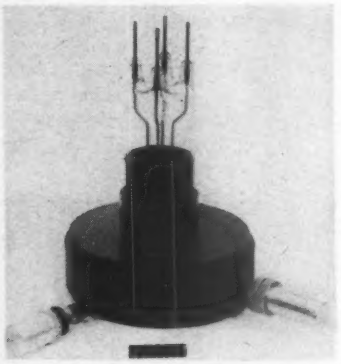
HUGHES PRODUCTS

© 1958, Hughes Aircraft Company

with power supply and projector system, can be transported over rough terrain."

Queried the Army: "Can present research in high temperature plasmas solve this problem? Can present research in sustained nuclear reaction solve this problem? Are there other techniques which should be investigated?"

The Army is planning a second feasibility study to find such a source.



Experimental model of pulsed M-type backward wave oscillator. New tube is electronically tuned over 17 percent bandwidth, delivers 150-kw pulsed power at S-band

Cite Advances In H-F Power Tubes

SUCCESSFUL ASSAULTS on the problem of high-power generation and high-level amplification of microwave frequencies are typified by two new tube developments revealed recently at a technical session at the IRE show.

A broadband, electronically tuned high-power device known as a pulsed M-type backward-wave oscillator was described as capable of delivering 150 kw of pulsed power tunable over a 17 percent range in S-band.

Basically a new version of the carcinotron backward-wave oscillator, the new tube was developed by the Companie Generale de Telegraphie Sans Fils of Paris under auspices of the U. S. Army Signal Corps.

Also described was a new medium-power traveling-wave amplifier, dubbed the Estiatron by its developers at RCA in Princeton. Unlike conventional twt's, the new amplifier requires no permanent magnet for electron-beam focusing. As a result, considerable weight reduction is achieved and less accurate alignment required.

The tube employs bifilar helixes to electrostatically focus a 50-ma electron beam. Gains of 20 db at outputs of 10 watts can be attained at S-band frequencies. At present, the noise figure of the tube is about 25 db, but low-noise tubes of this type are already in the design stage.

FINANCIAL ROUNDUP

• **Bausch & Lomb Optical,** Rochester, N. Y., acquires **Applied Research Labs,** Glendale, Calif. ARL is known for developments in industrial analytical control employing radiation measurements over the full spectrum. It will be operated as a wholly-owned B&L subsidiary. Stock of B&L, previously traded over-the-counter, was listed on the New York Stock Exchange last month.

• **Howard Industries,** electrical motor manufacturer of Racine, Wis., purchases **Lloyd Scruggs Co.,** Festus, Mo. Scruggs assets were purchased for $200,000 of Howard's 5 percent convertible debentures. Missouri firm manufactures shaded pole motors used in tape recorders, dictating and vending machines.

• **D. S. Kennedy,** antenna manufacturer of Cohasset, Mass., plans its first public stock sale. One hundred thousand shares of firm's common stock have been registered with the Securities and Exchange Commission. Price of stock has not yet been determined. But, company is looking for at least $750,000 from the sale. Some $500,000 of proceeds will be used for land, buildings, machinery, equipment and working capital for Kennedy's new research and development subsidiary in California. In addition, $250,000 will be used to construct additional factory floor space in Cohasset, company officials report.

• **Textron** acquires for undisclosed cash sum the **Microphone Division** of Elgin National Watch. American Microphone's operations will be moved to Rockford. Ill. There it will be operated as a division of General Cement Manufacturing, a division of Textron. American Microphone makes components used for broadcasting, tape recorders, public address systems and mobile units and phonograph and communication system parts.

• **International Railroad Weighing Corp.** of Chicago buys controlling interest in **Die-Form Circuits** and **Equip-A-Matic Engineering,** both of Cicero, Illinois. Die-form manufactures printed circuits while Equip-A-Matic produces automation assembly machinery for the electronic industry. Purchaser manufactures weighing systems for the railroad industry.

• **General Instrument,** components manufacturer of Newark, N. J., acquires remaining 14 percent of outstanding stock of **Radio Receptor** of Brooklyn, N. Y. GI had acquired a controlling interest in Radio Receptor, well-known as a supplier of selenium rectifiers, in April, 1957. Integration of the two firms is underway.

• **Hunter-Bristol Corp.** of Bristol, Pa., designer and manufacturer of ground handling and other support equipment, announces sale of its principal assets to **Thiokol Chemical Corp.**

Japanese Forming New Trade Group

TOKYO—JAPAN'S electronics industry last week took its first step toward organizing a trade association financed partly by the government. Four firms—Tokyo Shibaura Electrical Co., Japan Electrical Co., Yokogawa Electrical Works and Hitachi—got together to swing 40 others under the banner of the Japa-

3, 5, 10 watt axial lead Blue Jackets now available in values down to one ohm for increased usefulness in transistor circuits

Blue Jacket

MINIATURE AXIAL LEAD RESISTORS

Meet the need for closer tolerance power wirewound resistors with these thoroughly reliable, low cost Sprague Blue Jackets—available in a full wattage range from 3 to 218 watts. The miniaturized axial lead units shown here are now available in resistance tolerances to 1% and 2% as well as standard 5%. Blue Jackets are designed for utmost stability under extreme conditions. Leads are anchored securely to *resistor body* without danger of disturbing connection of lead and fine resistance wire when lead is flexed during installation. You can depend upon Blue Jackets for *simplified, safe* production and top performance characteristics.

SPRAGUE TYPE NO.	WATTAGE RATING	DIMENSIONS L (inches)	D	MAXIMUM RESISTANCE ± 1% TOL.	MAXIMUM RESISTANCE ± 5% TOL.
151E	3	1⅛	¾	1,000 Ω	10,000 Ω
27E	5	1⅜	⅝	5,500 Ω	30,000 Ω
28E	10	1⅜	⅝	12,000 Ω	50,000 Ω

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nese Electronics Development Association.

General organization meeting was held with the blessing of the Ministry of International Trade and Industry. Tentative prospectus calls for a government subsidy of $362,000 and annual membership fees of $84,000. Association aims to reduce the expense of foreign licensing agreements on individual firms; step up production above domestic requirements to expand exports; alleviate unprofitable competition among Japanese manufacturers.

Group would also streamline research efforts by assigning different projects to different companies. One other likely step: a computer center operated for member companies perhaps unable to afford their own computers.

On the export front, Japan produced 3,756,773 radio sets last year and exported an estimated one million, of which about 60 percent went to the U. S. Transistor radios now make up more than one-third of Japan's monthly radio output. Japan produced 1,339,355 tv sets last year, made its first big export sale late last year—3,000 units to Sweden.

MIT professors hold model of thermo-electron engine for converting heat directly into electricity. Device may become practical, inventors believe, for effective use of atomic energy in small power plants

Testing Thermo-Electron Engine

Two MIT PROFESSORS this week launched a two-year development project on a thermo-electron engine which will convert heat into electricity—without moving parts.

Joseph Kaye and George N. Hatsopoulos report the MIT model has produced electric power with thermal efficiencies of about 12%. They say efficiencies of about 30% may eventually be obtained.

The electron heat engine consists of two metallic plates inside a vacuum tube. Electrons are boiled off the hot plate—at about 2200 F—onto the "cold plate," maintained at about 1000 F. When the plates are connected with an external load, the electrons are conducted off to produce useful work.

And Did You Notice These?

EXHIBITORS pondering next year's IRE show certainly saw displays to think about at the recent one:

A "beheaded" brunette atop one firm's spiderweb display drew up to 200 engineers at a time while extolling virtues of eight-layer wrap-around insulation on hookup wire.

Outside Coliseum, food for thought came from a sandwich-board man. His sign: "See the I.R. Factor at Booth 2130." It was—a blurb for a potentiometer.

Back inside, a touch of Florida was in New York City. One firm, recruiting men for Florida plant, had name cards generously ornamented with palm trees.

MEETINGS AHEAD

Apr. 10-12: Tenth Southwestern IRE Conference and Electronics Show, St. Anthony Hotel and Municipal Auditorium, San Antonio, Tex.

Apr. 14-16: Conf. on Automatic Techniques, IRE, ASME, Statler Hotel, Detroit, Mich.

Apr. 18-19: Twelfth Annual Spring Tech. Conf. on Television and Transistors, Engineering Society of Cincinnati Bldg., Cincinnati.

Apr. 20-24: Scientific Apparatus Makers, 40th Annual Meeting, El Mirador Hotel, Palm Springs, California.

Apr. 21-26: Society of Motion Picture and Television Engineers, 83rd Convention, Ambassador Hotel, Los Angeles.

Apr. 22-24: 1958 Electronic Components Conf., IRE, AIEE, Theme: "Reliable Application of Component Parts," Ambassador Hotel, Los Angeles.

Apr. 24-26: National Academy of Sciences, U. S. National Comm., International Scientific Radio Union, Spring Meeting, Willard Hotel, Wash. D. C.

Apr. 27-May 1: National Assoc. of Broadcasters, 36th Annual Convention, Biltmore and Statler Hotels, Banquet in Hollywood Palladium, Los Angeles.

Apr. 28-30: Middle Eastern District Meeting, AIEE, Sheraton Park Hotel, Washington, D. C.

Apr. 28-May 1: Sixth Annual Semiconductor Symposium of the Electrochemical Society, Statler Hotel, N. Y. C.

Apr. 29-30: Symposium on Electronic Scanning of Antennas, AFCRC and Rome Air Devel. Command, L. G. Hanscom Field, Bedford, Mass.

Apr. 30-May 2: Seventh Regional Conf. and Trade Show, IRE, State Fair Grounds, Sacramento, Calif.

May 4-7: Fourth National Flight Test Instrumentation Symposium, ISA, Park Sheraton Hotel, N. Y. C.

May 5-7: Prof. Group on Microwave Theory and Techniques, PGMTT, Stanford Univ., Stanford, Calif.

May 6-8: Western Joint Computer Conf., First National Symposium on Modern Computer Design, Ambassador Hotel, Los Angeles.

May 12-14: National Aero. & Nav. Elec. Conf., PGANE, Biltmore Hotel, Dayton, Ohio.

May 13-15: Radio Tech. Comm. for Marine Services, Spring Assy., Ben Franklin Hotel, Philadelphia.

May 19-21: Electronic Parts Distributors Show, Hilton Hotel, Chicago.

May 19-23: International Convention on Microwave Valves, Institute of Electrical Engineers, contact secretary, Savoy Place, London.

May 27-28: Second EIA Conf. on Maintainability of Electronic Equip., Univ. of Penn., Phila.

electronics
engineering edition

APRIL 11, 1958

Servo Circuit Controls Artificial Heart

Rotating oxygenator substitutes for lung while servo-controlled pumps simulate heart action. Error signal from capacitance tranducer in oxygenator activates servo motors to maintain constant volume within the circulatory system as variable reluctance pickups monitor pressure. System responds to capacitance changes as small as 0.1 $\mu\mu$f

By R. SCHILD* and N. WESSON New Electronic Products Ltd., London, England

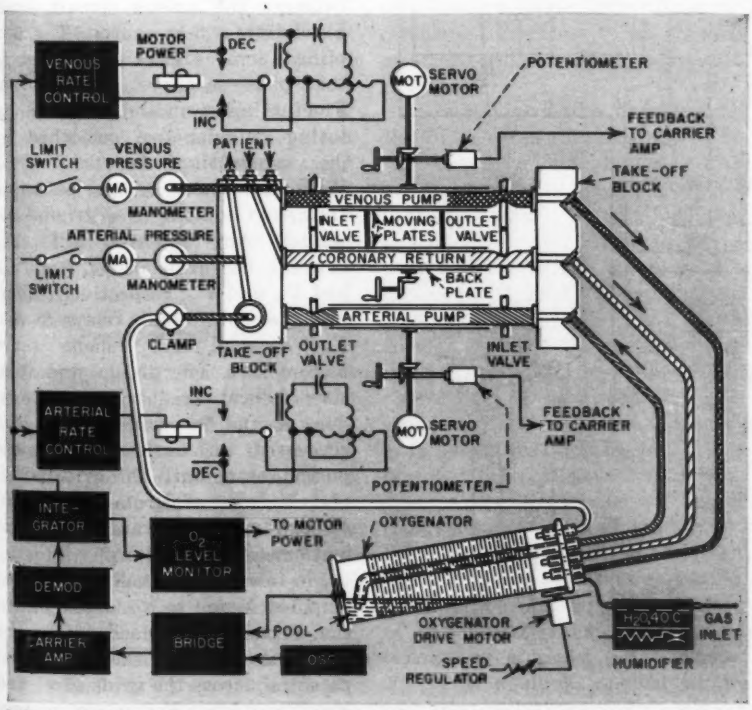


FIG. 1—Simplified diagram of circulation system showing servo feedback loop. Three plastic tubes squeezed between metal plates simulate heart action

WITH THE INTRODUCTION of a new technique to short-circuit the heart and lung of an animal to allow intracardiac surgery in a bloodless field, a great new interest in cardiac surgery has been stimulated throughout the world. The problem has been to produce an extra-corporeal device capable of temporarily maintaining the entire circulation of the human body. One approach to this problem by the Post Graduate School of Medicine, Hammersmith, London, England, culminated in the construction of a servo-controlled machine which serves three purposes: it temporarily carries some of the cardiorespiratory function when part or all of the natural process is impaired, it provides a complete diversion of the blood stream away from the chambers of the heart to permit intracardiac surgery, and it forces flow through isolated organs.

As shown in Fig. 1, the lung is

* Now with S. E. Laboratories, Ltd.

initiated by an oxygenator which is a rotating cylinder set at a slight angle to the horizontal. Blood flowing by gravity is spread over a large number of surfaces formed by disks projecting into the cavity of the cylinder. The complete assembly of the oxygenator can be likened to an Archimedean screw, by which the stream of blood passing through the cylinder is raised and lowered, spreading the blood in a thin film over a large surface, and hence exposing the red cells directly to a mixture of oxygen and carbon dioxide. The cylinder is rotated by a friction wheel driven by a variable speed motor. At maximum speed, the surface area exposed is approximately 120 m²/min.

Pump System

Venous and arterial pumps drive blood from the patient's venous system into the artificial lung and after oxygenation return it to the arterial system. Tubes leading from take-off blocks are attached to appropriate tubes placed into the superior and inferior vena cavea and subclavian artery. The coronary return pump removes the blood from the heart and returns to the machine any blood spilled during the operation.

The stroke volume output of the pump can be varied from 0 to 75 mltrs and at 72 pumping strokes per minute (normal heart rate for an adult person). The total output of the pump can be varied from 0 to 5 ltrs per minute. The valves are essentially miniature versions of the pumping plates and the cams operating them are arranged to provide a diastolic filling time of 55 percent with a systolic emptying time of 33 percent. Such a cycle provides a close imitation of the normal heart cycle.

The most important function of the servo control is to ensure that the volume of blood is constant within narrow limits under varying conditions.

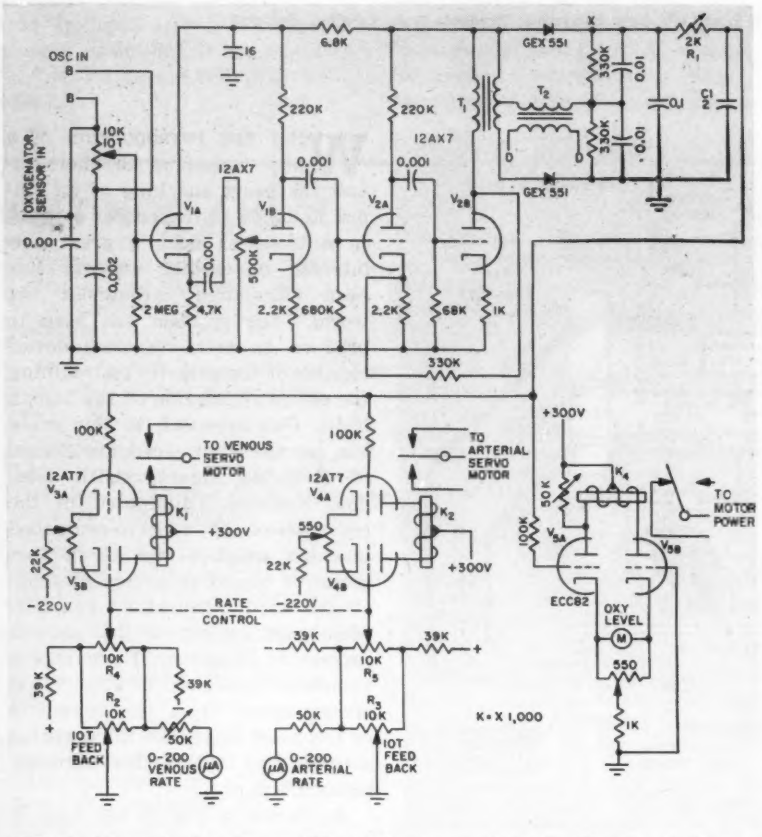
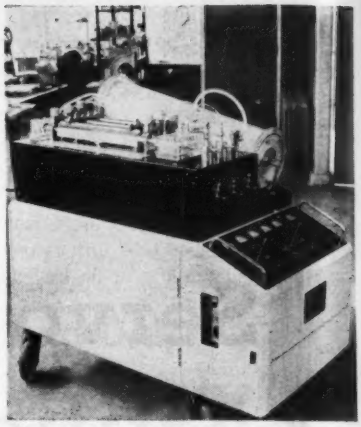


FIG. 2—Schematic of carrier amplifier and rate control circuit. Direction of closure of K_1 and K_2 determines increase or decrease of pump volume output



Closeup of machine affords view of pump mechanism and control panel

A true indication of the total volume of blood is given by the level of fluid at the lower part of the oxygenator. Electrical conversion from changes in blood level is achieved by inserting a brass disk into the end plate and sensing changes in the capacitance formed by the pool of blood and the brass disk separated by a plastic disk of 1 mm thickness.

The circuit employed is shown in Fig. 2. An error signal derived in the form of a capacitance change due to a change of blood level unbalances the bridge circuit energized from a 3-kc source. The amplified error signal is applied to the phase-sensitive demodulator. Fluctuating signals due to the rotating cylinder are smoothed by the integrating network C_1-C_2. With the input bridge balanced, voltage at point X is at ground potential. Any potential difference between the grids of V_{3A} and V_{3B}, and V_{4A} and V_{4B}, respectively, energize the center-stable relays K_1 and K_2. Arterial and venous servo motors are energized, and ten-turn helical feedback potentiometers R_2 and R_3, coupled to the lead screw of the back plate of the pump, rotate until the grids of V_3 and V_4 are at ground potential determined by the rate control potentiometers R_4 and R_5.

For example, a voltage derived at point X due to a sudden reduction in volume of blood within the oxygenator changes the differential potential across the grids of V_3 and V_4. Therefore, the servo motors drive the feedback potentiometers

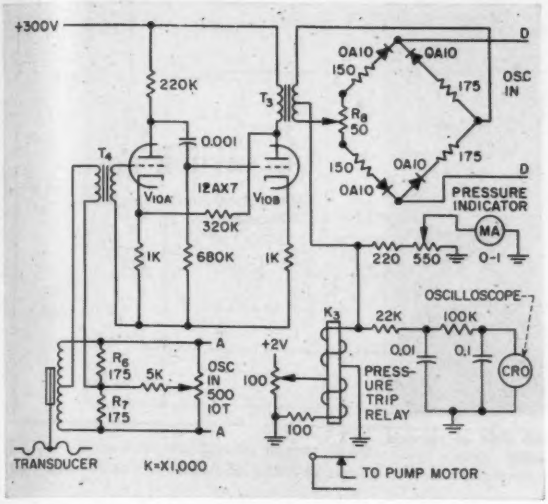


FIG. 3—Schematic of pressure indicator. Two are required

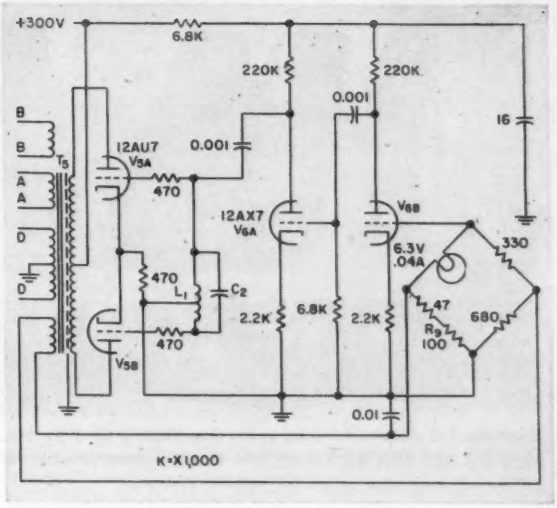


FIG. 4—Carrier L-C oscillator provides 4 v rms at 3 kc

until the differential voltage between the grids is equalized. The direction of rotation is such that the stroke output of the arterial pump is decreased while that of the venous pump is increased. The effect is to rapidly restore the volume of blood previously selected within the machine. The proportional bandwidth for maximum stability of the control loop is set by R_1.

The time constant of the integrator is important as it effects the response of the system. If it is too short the control relays will respond to oscillations in the blood level produced by the rotating cylinder, and if it is too long the delay in the response of the servo motors may produce large changes in blood level before correction is applied.

Pressure Indicator

During operation it is important to monitor the pressure within the venous and arterial system continuously and provide means for shutting off the pump motors in the event of high pressures destroying the tubes leading to the patient. Translation of pressure into an equivalent electrical signal is achieved by a pressure transducer of the variable reluctance type. Essentially, this consists of the coils wound concentrically on a nonmagnetic former. A ferromagnetic core placed centrally between the two coils is attached to a diaphragm, forming an inductive half-bridge; any deflection of the diaphragm due to pressure pulses unbalances this system and produces differential changes in the value of the two inductances. For easy sterilization, the coil assembly is mounted inside the barrel of a standard syringe which carries the diaphragm at one end. A needle attached to the syringe enables the complete transducer to be plugged in at any point within the hydraulic circuit.

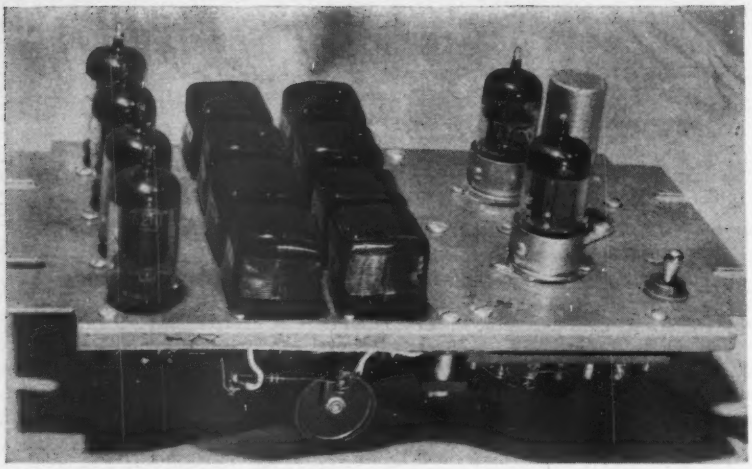
The circuit of the pressure indicator is shown in Fig. 3. The full bridge is completed by the paired resistors R_6 and R_7. Any unbalanced voltage is amplified and demodulation is effected by a bridge circuit which operates as a rectifier with phase discrimination. The secondary of the output transformer T_3 feeds the amplified signal voltage across one diagonal of the bridge. A larger carrier voltage is fed directly from the oscillator across the other diagonal. The demodulator acts as a switch that opens and closes one or another of the resistance arms of the bridge. With no signal from the amplifier, the bridge is set for zero output between the center-tapped secondary of the output transformer T_3 and chassis by a preset potentiometer R_8. With a signal applied to the amplifier, only those components are admitted to the ring demodulator which are in phase or 180 degrees out of phase with the reference carrier voltage, giving a positive or negative swing on the meter.

L-C Oscillator

The L-C type oscillator of Fig. 4 provides a carrier voltage of 4-v rms at a frequency of 3 kc to the servo amplifier and to both the venous and arterial pressure indicators. Amplitude stabilization is affected by a bridge feedback network which utilizes a filament type lamp as a nonlinear element in one arm of the bridge. Basically, the oscillator is a tuned high-gain amplifier with a push-pull output stage. L_1-C_2 constitute the tuned circuit components which also acts as a phase-splitter. Positive feedback is derived from a tertiary winding on output transformer T_4 (Fig. 3). With the feedback bridge off balance, the circuit oscillates and the resistance of the lamp increases, making the feedback less positive and maintaining constant amplitude, the value of which is set by R_9. (Fig. 4).

The experimental design work was carried out under the guidance of Dr. D. G. Melrose and made possible by a financial grant from the Nuffield Organization.

In the preparation of this article much information was derived from previous articles published in medical journals by Dr. D. G. Melrose and his colleagues.



Complete 525 divider occupies space less than 4 by 5 by 2 in. on left side of chassis. Oscillator and discriminator portions of sync generator are on right side

By ARTHUR ROSE

Magnetics Research Company, White Plains, N. Y.

Magnetic-Core Dividers

Frequency-divider chain uses pairs of rectangular hysteresis-loop magnetic cores as counting elements. Operating as digital device, circuit has high accuracy and stability with complete freedom from adjustment. Lack of adjustments suggests potting of circuit along with transistorization

HIGH ACCURACY and freedom from periodic adjustments are not fully realized in sync-generator dividing circuits that utilize multivibrators or blocking oscillators.[1] A recent approach to this problem is a digital magnetic countdown device, the Magnivider, which offers accuracy and adjustment-free stability, as well as an attendant advantage of space reduction. The circuit is unaffected by power supply potential variations over a large range; lack of frequency-sensitive networks results in excellent temperature stability.

Basic Circuit

In its basic form, the divider circuit comprises a pair of rectangular hysteresis loop cores, as shown in Fig. 1. The first core, the ladle, is driven to saturation by each input pulse. The constant-voltage integral output from the ladle core drives the second bucket core. By using appropriate turns ratios between the windings of the ladle and bucket cores, the bucket core can be made to walk up its hysteresis loop in any number of predetermined steps, as illustrated in Fig. 2.

Application of constant-voltage integral steps corresponding to each count to the bucket core continues until the bucket core reaches saturation. At saturation, the impedance looking into a winding on that core becomes quite small and the core cannot support any voltage.

A voltage-divider network is formed by L_s and R_L in Fig. 1. So long as the bucket core is not saturated, a proportionate voltage appears across R_L with each voltage-integral pulse from the ladle. However, the final pulse saturates the bucket and almost the entire voltage appears across R_L. This higher potential triggers the normally cut off

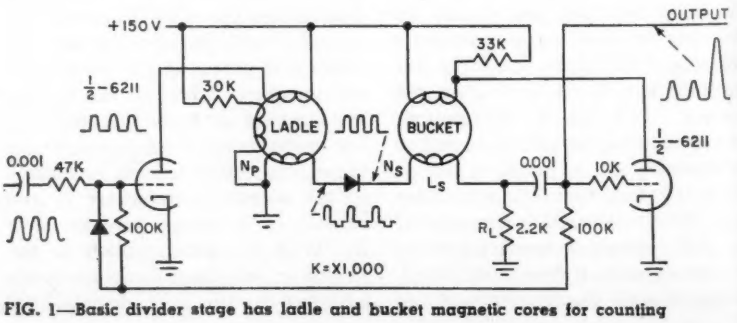


FIG. 1—Basic divider stage has ladle and bucket magnetic cores for counting

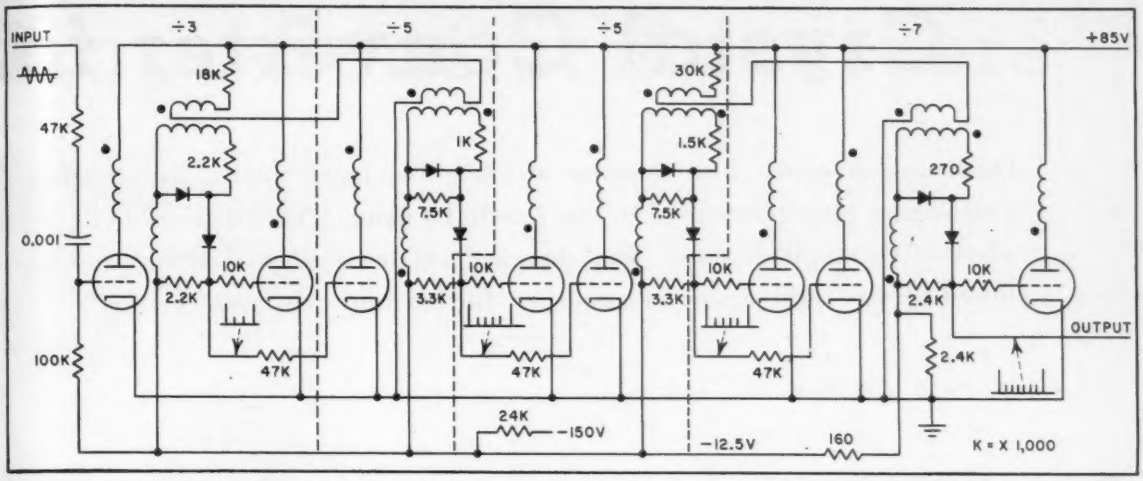


FIG. 3—Magnetic-core divider counts 31.5-kc input signal down by 525 to produce 40-v 10-μsec ouput at 60 pps rate. The bias windings are series connected in pairs to reduce circuit complexity. The first two cores require greater bias than the latter two

for ITV Sync Generators

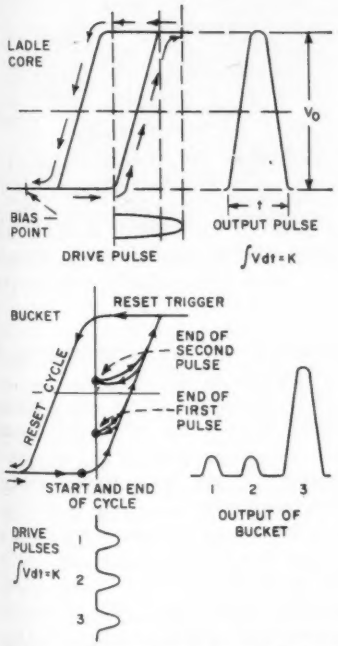


FIG. 2—Input and output signals for ladle and bucket cores

triode which generates a large pulse that resets the bucket core by applying reverse flux.

The ladle core drives the bucket through a diode network that prevents reversed polarity currents from going through the bucket. The undershoots reset the ladle after each count. An additional winding on the ladle core sets the operating flux for that core at the bias point indicated in Fig. 2.

Tight control of the voltage-integral steps to the bucket is obtained by the sharply defined saturation characteristics of the ladle. Cores with like characteristics are used, with the turns ratios roughly controlling the count. However, a large number of second-order effects make it difficult to exactly calculate these values.

As a digital device, errors occur as integral counts. For example, past certain operating points, the scale of a scale-of-10 divider will jump to 11. Variations of 10 percent of plate and bias potentials and heater variations to as low as 4.5v produce reliable operation. No components are temperature sensitive other than the diodes and these have little effect.

Successful single-stage dividers have been made up to scales of 17 and it is probable that higher scales will be developed. Stages may be cascaded indefinitely.

Most applications require lowest possible current drain. For these cases, the negative bias supply illustrated in Fig. 1 is used. Where drain can yield to convenience, bias may be obtained by elevating the cathodes and using a bleeder from B plus. This method also has the advantage of eliminating a possible variable and therefore provides better reliability. The bleeder must be quite stiff, however, to present a low impedance.

Figure 3 shows a typical divider chain as used in an itv sync generator. With the separate bias supply, total drain is of the order of 15 ma, mostly from B plus.

The excellent reliability of the circuit may be seen from Table I. Reliable operation is obtained over a range of 10 to 50 kc.

Table I—Input Levels Required for Various Operating Potentials

Bias	B+	Heater	RMS Input
−150 v	85 v	6.3 v	16 to 30 v
−150 v	85 v	4.5 v	18.5 to 30 v
−135 v	85 v	4.5 v	14 to 30 v
−165 v	85 v	6.3 v	23 to 30 v

Reference

(1) Haig A. Manoogian, Simple Sync Circuits Time ITV Systems, Electronics, p 174, Mar. 1957.

Crystal Converter for T

Quadruple-diversity f-m receiver utilizing baseband combining achieves noise-figure improvement of 0.5 to 1.5 db by using 1N21E silicon diode in place of r-f amplifier stage. Well-designed single-ended coaxial mixer, followed by low-noise-figure i-f amplifier, further improves performance

By **PAUL GRUBER** Project Engineer, Radio Engineering Laboratories, Inc., Long Island City, N. Y.

AVERAGE PATH LOSSES of about 75 db, below free space in the 1 to 2-kmc region, for tropo-scatter circuits of 200 miles makes the lowest possible value of receiver noise figure an absolute requirement.[1]

A noise figure improvement of 0.5 db to 1.5 db over an r-f amplifier-tube receiver can be obtained by use of a 1N21E silicon diode in conjunction with a well designed mixer that is immediately followed by a low-noise-figure i-f amplifier. Elimination of the r-f amplifier also offers a substantial cost saving.

As tropo-scatter circuits are characterized by periodic fading, receiver diversity operation is a necessity since the system reliability factor increases proportionately with an increasing number of receivers in diversity. Figure 1 shows a typical block diagram of a quadruple-diversity f-m receiving system utilizing baseband combining. All four receivers are physically and electrically identical.

Figure 2 shows a complete block diagram of one of the diversity receivers tuning from 750 to 1,000 mc (1 kmc). Receivers covering 1,700 to 2,400-mc (2 kmc) are identical, with the exception of slight differences in the preselector and oscillator sections of the converters.

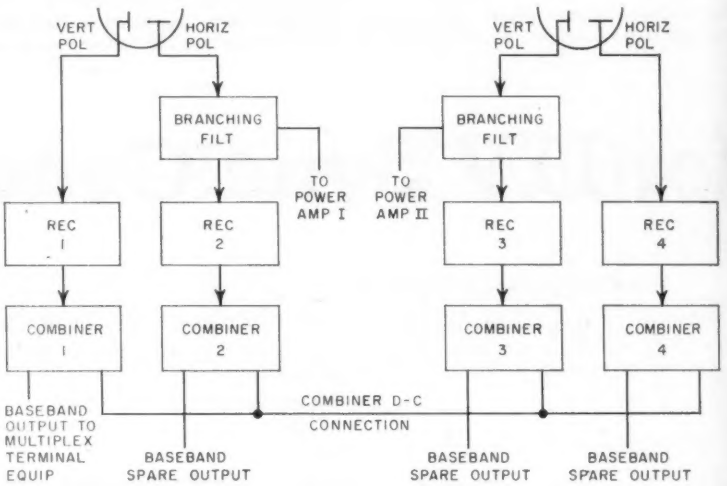


FIG. 1—Typical f-m quadruple diversity receivers used in the tropo-scatter system depicted on the front cover

Converter

The converting process is crystal controlled. Plug-in filters provide 3.5-mc, 800-kc or 275-kc bandwidths.

For a peak deviation of ±500 kc and an intermodulation distortion not to exceed −53 db, an i-f bandwidth of 3.5 mc is sufficient. An increase in bandwidth would reduce the receiver sensitivity. As the receiver has no r-f amplification and uses single conversion, the selection of the i-f frequency is mainly a function of the noise figure and the preselector design considerations. An intermediate frequency of 30 mc is optimum.

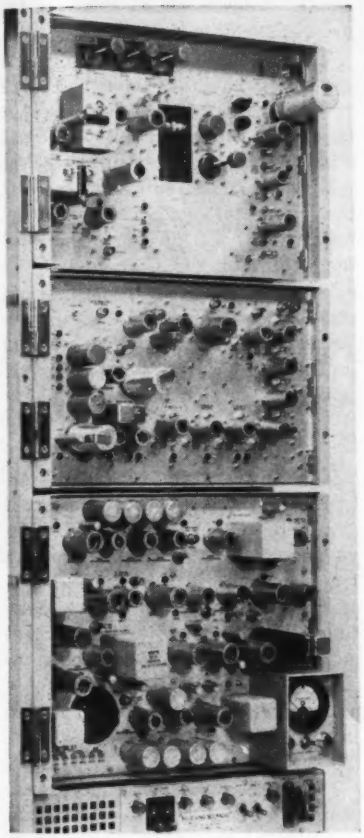
The peak deviation of the system must be reduced when the receiver bandwidth is reduced, with a consequent reduction in channel capacity. As an example, for a four-channel, 4-kc wire system, an i-f bandwidth of 275 kc is sufficient. The intermodulation distortion is at least −53 db, using a peak deviation of ±50 kc. For this condition, the receiver threshold is improved by 11 db compared to a 3.5-mc bandwidth.

The demodulator is of such a design that 1 mv of signal from the converter will give complete limiting at the last clipper stage. Therefore, the required converter gain has to be at least 60 db for a 3.5-mc bandwidth and 70 db for a 275-kc receiver bandwidth to obtain limiting for thermal noise. Receiver production runs show that consistent i-f noise figures of 1.1 db at 30 mc are obtainable.

The 1N21E is rated at 7 db if followed by a 1.5 db i-f stage. Considering a 1.1-db i-f strip, a 1N21E noise figure rating of 6.6 db can be assumed. These ratings illustrated in Fig. 3, justify the elimination of the r-f tube.

Considering overall receiver de-

Tropo-Scatter Receivers



Front panel of f-m receiver showing converter, demodulator and condenser

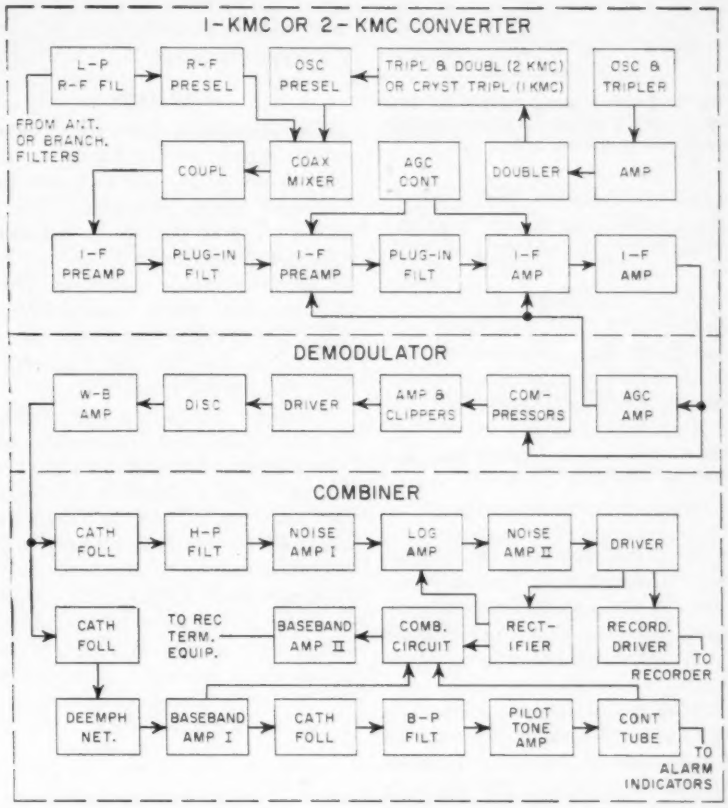


FIG. 2—Diversity receivers for 1-kmc and 2-kmc range are identical except for slight differences in preselector and oscillator sections of converter

sign, especially with respect to the large tuning range, a single-ended coaxial mixer is more practical than a balanced version.

Manufacturers rate crystals in terms of noise figure based on $N = L_c\ (N_{i\text{-}f} + N_r - 1)$ where N = overall noise figure (power ratio), L_c = crystal conversion loss (power ratio), N_r = noise temperature ratio (power ratio) and $N_{i\text{-}f}$ = i-f noise figure (power ratio). To achieve optimum receiver noise figure, and to make the noise figure only a function of the i-f noise figure, the crystal conversion loss and the crystal noise temperature, and all r-f power losses ahead of the i-f section have to be kept at an absolute minimum.

The r-f power losses that must be considered in the crystal mixer design can be outlined as follows:

(1) Losses due to poor conductivity of mixer circuits: Experimental results have shown that silverplating (0.4 mil) plus rhodium flashing (0.1 mil) of the brass mixer cavity offer excellent conductivity to the uhf frequencies in question.

(2) Loss of signal into oscillator injection circuits: Because the mixer is single ended, it is desirable that the isolation between injection source and mixer be about 10 db. This means that 10 mw of injection power has to be available to develop approximately 1 ma of crystal current.

Only a fractional deterioration, about 0.1 to 0.3 db, in noise figure occurs when the available oscillator power is reduced to 4 mw. Below 4 mw the r-f losses approach square-law proportions.

(3) Swr consideration and i-f reflection: Practical considerations plus good design practice require a receiver input swr of at most 1.25 over a bandwidth equivalent to the i-f bandwidth. It becomes a necessity for the mixer cavity to have a swr of better than 1.25 over a bandpass of 1.5 to 2.5 times the i-f bandpass. The simplest approach to this problem is to make the r-f input to the mixer cavity a slider arrangement which permits a 50-ohm tap selection on the inner conductor.

Due to the crystal loading, the bandwidth is no particular problem. Both capacitive tuning (capacitive loading at the high-voltage point) and inductive tuning (lengthening or shortening the

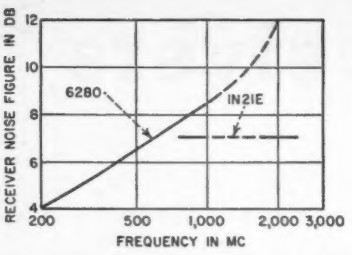


FIG. 3—Receiver noise figures for 6280 tube or 1N21E crystal including 0 to 5-db preselector losses for both

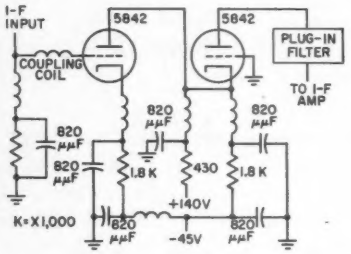


FIG. 4—Two stage i-f amplifier has noise figure of 1.1 db

mixer cavity) are provided to cover the tuning range of the uhf spectrum. In the 1-kmc region, the capacity is tuned to a $\frac{1}{4}$ wavelength and at 2-kmc it is tuned to a $\frac{3}{4}$ wavelength.

By designing the i-f coupling network sufficiently wide, 12 mc for an i-f bandpass of 3.5 mc, i-f reflections are eliminated. The limiting factors in bandwidth are dictated by the output capacitance of the crystal mixer, which is a function of both the i-f input and stray capacitance, and of the optimum transformed source resistance of the i-f input.

The i-f amplifier shown in Fig. 4 uses two 5842 tubes in a series circuit. The cathode lead inductance was increaesd by introducing a 0.08-μh coke for additional degeneration thereby lowering the input impedance of the tube. The noise figure of the circuit which is about 1.1 db is not noticeably deteriorated by the cathode degeneration, mainly due to the high power gain of the 5842.

(4) Preselector insertion losses: The 750- to 1,000-mc and 1,700- to 2,400-mc spectrum cannot be covered with physically and electrically identical preselectors and still meet all necessary specifications.

To cover the 1-kmc region, use is made of a rectangular coaxial type preselector, using three resonators tuned to a quarter wavelength. Each resonator is $3\frac{1}{2}$ sq in. and loop coupled. The plating is the same as that used in the mixer cavity. The size, dictated by available space, still permits an unloaded Q of about 3,000 per resonator.

Bandwidth

The maximum theoretical bandwidth cannot exceed 14 mc at the half power points and still give the required image rejection. This is based on 6 db per octave attenuation per resonator and does not include attenuation resulting from the coupling loops. The coupling loops are actually rather critical in nature, as they are not readjusted over the tuning range.

Constant bandwidth (increasing Q with increasing frequency), 50-ohm resistive input and output impedance, and a constant minimum loss over the r-f tuning range are obtained in production units, with the exception of a slight variation in bandwidth. Actually, the results at any r-f frequency in the tuning range are a maximum insertion loss of 0.5 db, a minimum rejection of 60 db at the image frequency and a swr of not more than 1.15. To eliminate any response exhibited by the preselector when the r-f frequency is three times the preselector frequency, a low-pass filter (causing an additional insertion loss of 0.1 db) is inserted at the preselector input.

The 2-kmc preselector makes use of four coaxial resonators, each resonator again being $3\frac{1}{2}$ sq in. The input and output are loop coupled, and the interstage coupling is of the iris type. Irises, suitably placed in the resonator walls, show an approximately 24 db per octave attenuation for the four cavity preselectors. Experiments confirmed this slope to more than 3 octaves beyond center frequency of both limits of the tuning band. The preselector insertion loss is 0.7 db.

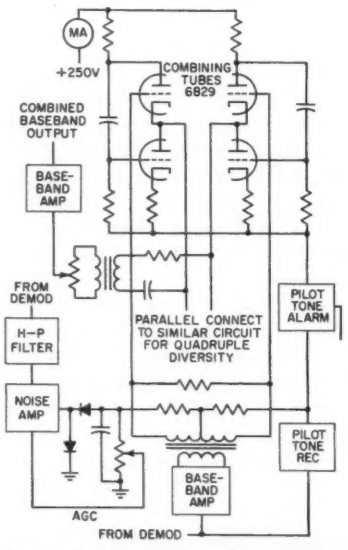


FIG. 5—Dual-diversity combining system can be made into quadruple-diversity system by connecting another identical circuit in parallel as indicated

Mixer Injection Power

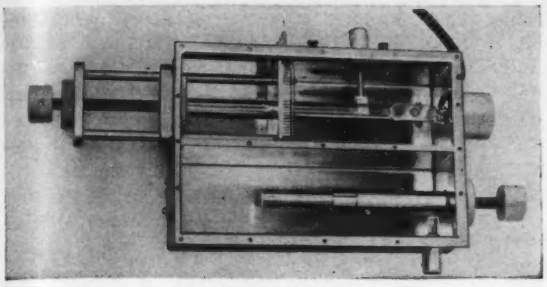
Ten mw of quartz-crystal-controlled mixer injection power is available to convert the carrier frequency to an i-f frequency. Since a frequency stability of ± 0.001 percent over a 72-C temperature variation and a 40-percent tuning range is required, a crystal-controlled oscillator and a subsequent frequency multiplication of 18 and 36 are used in the 1- and 2-kmc systems respectively.

Figure 2 shows tube multiplication with the exception of the last stage, which uses 1N278 germanium diodes to triple up to 1,000 mc for the 1-kmc receiver. The third harmonic power which is nominally 10 mw is selected in a coaxial cavity. As the last two stages in the 2-kmc receiver multiply from the 400- to the 2,400-mc region in their upper tuning range, use is made of two GL6442 coaxial triodes operating as a grounded grid doubler and tripler. The low input impedance of these tubes permits broadband, fixed coupling over the tuning range.

The coaxial plate circuits of the doubler, tuned to $\frac{1}{4}$ wavelength, and the tripler, tuned to $\frac{3}{4}$ wavelength, are tuned by sliding shorting bars.

Receiver Noise Figures

The median noise figures of 60 receivers in the 1-kmc region were tested at 7 db, the maximum spread being 6.4 to 7.4 db. This number includes the losses of a $1\frac{1}{2}$ ft RG8/U



Inside view of 1-kmc receiver mixer box

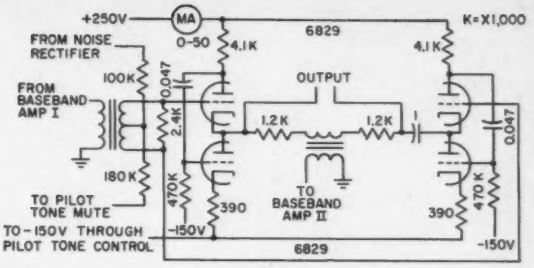


FIG. 6—Circuitry of combining tubes shown in Fig. 5

cable, a coaxial low-pass filter, and a three-cavity preselector.

Conservatively, these losses are at least 0.6 db. This reduces the crystal noise figure to 6.4 db.

The average noise figure in the 2-kmc region was tested at 7.2 db, the maximum spread being 6.8 db to 7.6 db. This number includes preselector and connector losses of at least 0.8 db. No precise noise figure data for the 6280 at 2-kmc is available, but it is estimated that the noise figure is in the neighborhood of 11.5 db.

A test of 1N21E crystal uniformity was performed at 2,000 mc. On a production receiver, 23 different 1N21E crystals were tried without retuning the mixer or any other part of the receiver. Twenty crystals showed a spread between 6.7 to 7.4 db; three crystals were 6.5, 7.7 and 7.9 respectively.

Noise figure tests were performed at an ambient temperature of 25C. Tests at an ambient temperature of −8 C showed an improvement in noise figure of 0.4 db. As the i-f noise figure is constant at −8 C and the preselector insertion losses do not change, the improvement results entirely from the 1N21E crystal. At an ambient temperature of 70 C in the receiver cabinet the noise figure increased by about 0.4 db.

In both the 1-kmc and the 2-kmc region, experimental tests and production runs have confirmed that the crystal current for optimum noise figure is about 1.3 ma for the 1N21E. No particular change in noise figure between 1 to 1.6 ma was noticed. On the average, the noise figure deteriorates below 1 ma.

Below 0.6 ma, all benefits of the 1N21E are lost. Above 2.5-ma crystal current, the noise figure deteriorates, which is to be expected, as the noise temperature increases faster than the conversion losses decrease.

Five ma of crystal current over periods of hours did not damage the crystals that were tested. No permanent noise figure deterioration due to this crystal current was noticed.

Two receivers were overloaded for short periods of time to produce crystal currents in excess of 10 ma. No permanent crystal damage could be found and the crystal noise figures were not deteriorated.

Demodulator

The requirements of rapidly acting limiters, maximum interference suppression, complete limiting for a threshold signal, low distortion and the requirements of constant demodulated output above threshold within 0.25 db over a 90-db r-f signal range complicate the demodulator design considerably.

In the limiter-demodulator the i-f signal is first symmetrically and rapidly compressed by three pairs of germanium diodes. After additional amplification, two clipper stages are employed using biased diodes. Again, rapid symmetrical

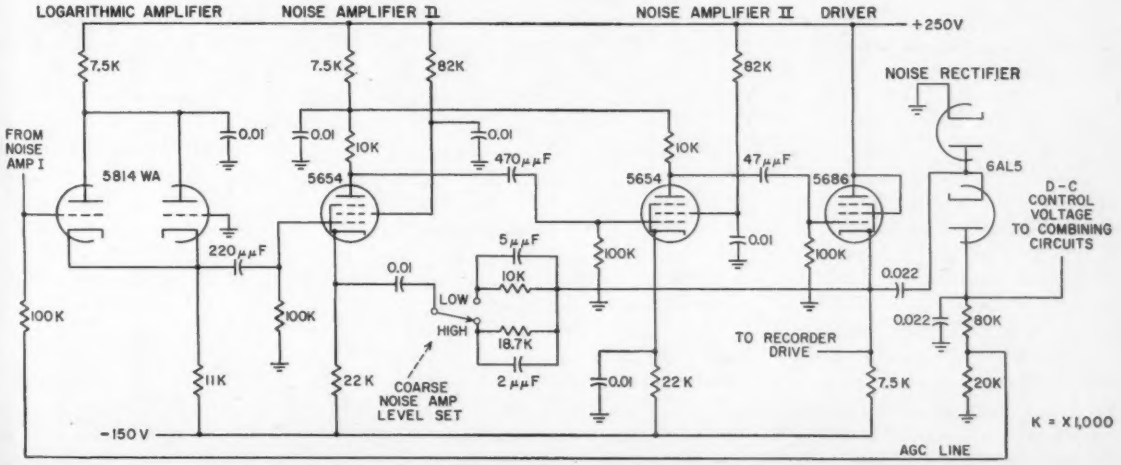
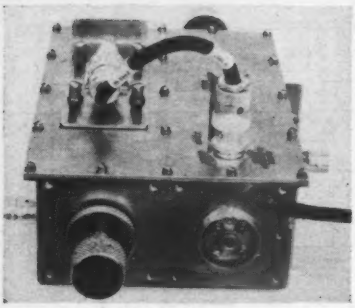


FIG. 7—Out-of-baseband noise is amplified logarithmically and used to control grids of combiner tubes



Receiver converter mixer box

clipping for signal levels in excess of 2 volts occurs. The speed of response is not impaired by coupling capacitors, as the average charge across the coupling capacitors does not change. All crystal coupling amplifiers are operated under constant current conditions and do not perform any d-c clipping.

The limiter-amplifier bandwidth is extremely wide and reflects itself in absolute limiting over a 13-mc bandwidth at the discriminator driver stages. The discriminator is of the current-difference type and exhibits a peak-to-peak separation of 6 mc. The linearity of the demodulator is of such a degree, that for a deviation of ±500 kc the intermodulation distortion, measured by noise loading,[3] is better than 0.14 percent.

For the degree of limiting employed, constant demodulated baseband output above the receiver threshold must take place. The baseband amplifier is 5-mc wide and is required to carry both baseband signals and out of band noise which is used in the combiner for control purposes. Distortion is below 0.05 percent and the gain stability is 0.1 db up to the point of tube failure.

Combiner

For reliable tropospheric communication, it is desirable to maintain the s/n ratio of the receiver output equivalent to s/n ratios of median r-f signals at least 99.9 percent of the time. Experimental and statistical data indicate that triple, or preferably, quadruple receiver diversity is necessary to achieve this reliability.

Figure 5 shows a combined block and schematic presentation of a dual-diversity combining system, with the combining tubes operating in push-pull. For a quadruple diversity system, the circuit of Fig. 5 is doubled with the cathodes of the upper combining tubes parallel connected. Figure 6 shows the detailed circuitry of the combining tubes.

Combiner Action

Consider first a case where the r-f inputs of all receivers are equal and above threshold. Under these conditions, the demodulated baseband signals of all receivers are equal in amplitude and in phase. The s/n ratios are also identical. This statement is justified because the demodulator is of such design that a modulated r-f signal, fluctuating between 10 to 90 db above threshold, will not show more than a 0.25-db amplitude variation of the demodulated baseband signal.

Since all receivers are identical, no phase shift relative to the individual receivers is introduced if the antenna feed lengths are reasonably identical. Should the antenna feed lengths be markedly different and the baseband extends, as an example, beyond 400 kc, simple phase compensation at the i-f frequency can be made. For this purpose a particular length of coaxial cable, such as RG58/U, can be used.

Assuming baseband signals of unity amplitude appearing at the respective combiner grids of the receivers, a unity amplitude signal will then appear at the cathodes of the combining tubes due to common loading. The noise which was assumed to be equal at both combiner grids is uncorrelated. It will add as the square root of the sum of the squares and because of the common loading of the combiner tubes, it will appear at the cathodes as 3 db less than on the grid input. The above conditions require the difference in bias between combiner grids with respect to ground to be zero.

If the r-f inputs to the diversity receivers are unequal and, as an example, differ by 6 db, the baseband signal-to-noise ratios appearing at the two combiner grids differ by 6 db. The s/n of the combined baseband output in diversity is still improved by up to a factor of 1.8 db as compared to the better s/n ratio of the two uhf receivers.

Each combiner stage is stabilized by more than 20 db of feedback to eliminate any possible nonlinearity which would contribute to intermodulation. Intermodulation is below 66 db under any possible operating condition and no distortion is introduced due to control bias variation.

If the amplitudes of the baseband signals appearing at their respective combiner inputs are of unequal magnitude, distortion can be introduced.

To maintain the baseband amplifier stability to within 0.25 db, 44 db of feedback is introduced for a gain of 32 db preceding the combiner. As the demodulator stability is within 0.25 db, the total baseband amplitude variation cannot exceed 0.5 db. Therefore, unless component failure takes place, a combiner grid unbalance of more than 1 db can never exist; this unbalance can easily be tolerated.

Noise Amplifier

In f-m receivers, the demodulated noise varies inversely at the r-f signal above threshold. The noise voltage rises triangularly up to half the i-f bandwidth and decreases as a function of the slope of the i-f amplifiers. No deemphasis is assumed. If the out-of-baseband noise is amplified, a voltage is available to control the combiner grids.

To accommodate the necessary differential combiner bias voltages, the noise amplifier transfer function is essentially logarithmic with a slope of 5 to 7 db per octave.

The amplifier control range extends 35 to 40 db above threshold, which is usually near the median signal; the s/n ratio of the highest baseband channel is 70 db. This value cannot be further improved by combining. A partial schematic diagram of the noise amplifier is shown in Fig. 7.

This project was carried out under the direction of James R. Day.

References

(1) K. Bullington, Characteristics of Beyond-the-Horizon Radio Transmission, *Proc IRE*, p 1,175, Oct. 1955.

(2) C. L. Mack, Diversity Reception in UHF Long-Range Communications, *Proc IRE*, p 1,281, Oct. 1955.

(3) J. R. Day, Beyond-Horizon Signals Extend Communications, ELECTRONICS, p 122, Oct. 1955.

Operator (left) presses timer start button permitting crt picture to appear. Time exposure is being made on single frame in still camera. After 1/30 sec, timer blanks out crt operator (right) closes shutter

Timer Shutters CRT for Single Frame Photos

Electronic timer uses four thyratrons to switch on crt picture for 1/30-second interval required to exactly complete two interlaced tv fields. Vertical drive pulses from tv sync generator provide time-reference triggering. Clean, single-frame photographs of the presentation are made with open-shuttered still camera. Stabilized high-voltage supply minimizes defocusing

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Research Laboratories, Eastman Kodak Company, Rochester, New York

IT IS OFTEN DESIRABLE and sometimes necessary to make single-frame photographs of kinescope presentations. Until recently the only available recording technique involved the use of special television cameras and film in motion picture length. The timing device discussed here permits the operator to make single-frame exposures with an ordinary still camera.

To retain normal exposure conditions while exposing only a single frame of film, it is necessary to restrict the exposure time to exactly two interlaced television fields. Each field lasts 1/60 of a second; therefore, the shutter on an ordinary still camera cannot be used since it does not possess the required accuracy and efficiency and would be difficult to synchronize with a tv system.

These difficulties could be avoided by making a much longer exposure of known time duration through suitable neutral densities. Owing to reciprocity failure and intermittency effects in photographic emulsions, this procedure leads to inaccurate and sometimes misleading results.

It appears that the best way of solving the problem is to use a still camera with a simple shutter which can be set on TIME to control the actual time of exposure. This can be accomplished by using an electronic shutter, or timer, to initiate

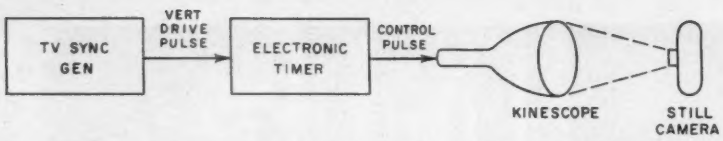

FIG. 1—Block diagram showing relationship of timer to other components. First drive pulse to enter timer after start button is pressed causes picture to appear on crt, second sets a thyratron in the timer and third triggers the thyratron removing crt presentation

the operation of the kinescope recording tube.

Performance Requirements

The timer must electronically activate a kinescope tube and restrict the display time on the face of the tube to two consecutive television fields. This requirement at once suggests the possibility of triggering the timing circuit from a 60-cps a-c source. However, since color television signals are not synchronized to the a-c lines but to a crystal synchronizing generator, an unsuitable field frequency of 59.94 cps is obtained. It is necessary, therefore, to trigger the timer with synchronization pulses derived from a television synchronizing generator or from the television signal itself.

Timers synchronized by horizontal sync pulses have previously been constructed.[1] Although accurate, this method requires complicated counting circuits. To take a single frame picture, a timer of this type would have to energize the kinescope, count exactly 525 horizontal sync pulses and then deenergize the kinescope.

A block diagram of a simpler method used in the timer described here is shown in Fig. 1. The kinescope is cut off until the timer circuit is activated by an operator. When the first vertical drive pulse reaches the timer circuit, the kinescope is energized and operates normally during the time of vertical retrace. The first television field is then presented on the face of the tube.

When the second drive pulse arrives, the operating conditions of the kinescope do not change; therefore the presentation of the second interlaced television field is not affected. When the third drive pulse reaches the timer, the kinescope is cut off until the circuit is reset by the person operating equipment.

A schematic diagram of the circuit developed to automatically control the timing sequence is shown in Fig. 2. With start switch S_1 in the closed position, thyratron V_1 is set to trigger when the first vertical drive pulse arrives. Conduction by V_1 results in a sudden rise of its cathode potential which applies a plate potential to thyratron V_2. At the same time, V_4 is triggered which changes the bias of the kinescope and brings it from a cutoff state to some preselected operating condition. The second vertical drive pulse reaching the timer has no effect on the kinescope but does trigger V_2. This applies a plate potential to V_3 and sets it for triggering by the third vertical drive pulse. When the third pulse arrives, the cathode potential of V_3 suddenly rises. This quenches V_4 which cuts off the kinescope. The whole circuit is inoperative until the plate potential of V_1 is switched off by reset switch S_2.

Since the amplitude of the positive drive pulses available for triggering the timer is normally only 4 volts, bias control R_1 was added to insure correct pretriggering conditions for the thyratrons. By adjusting this control, the maximum positive potential can be applied to the grids of the thyratrons to keep them permanently in a conducting state. Thus, the action of the timer is nullified and the kinescope maintained in a normal operating condition for as long as required. Throughout this period, the beam current, which at constant anode voltage determines the radiance of the kinescope, can be set to any value that may subsequently be required for exposing the film by adjusting voltage control R_2.

Retrace Blanking

Resistors R_3 and R_4, capacitors C_1 and C_2, and the connection to the vertical sweep output transformer were added to the circuit to provide retrace blanking. This permits the kinescope to operate at any required radiance level. If this were not done, bright retrace lines would appear on the face of the kinescope at high radiance settings.

External configuration of the timer unit is shown in Fig. 3. The

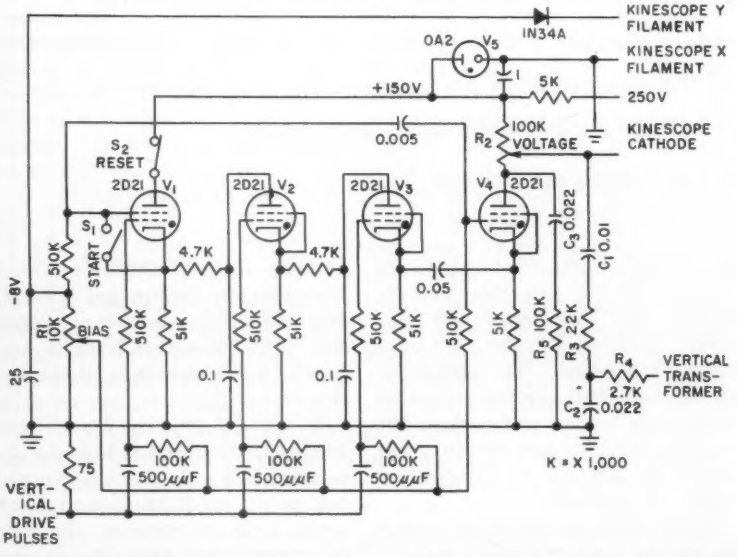

FIG. 2—Schemaic diagram of electronic timer. Voltage regulating tube V_5 stabilizes the 150-v plate supply

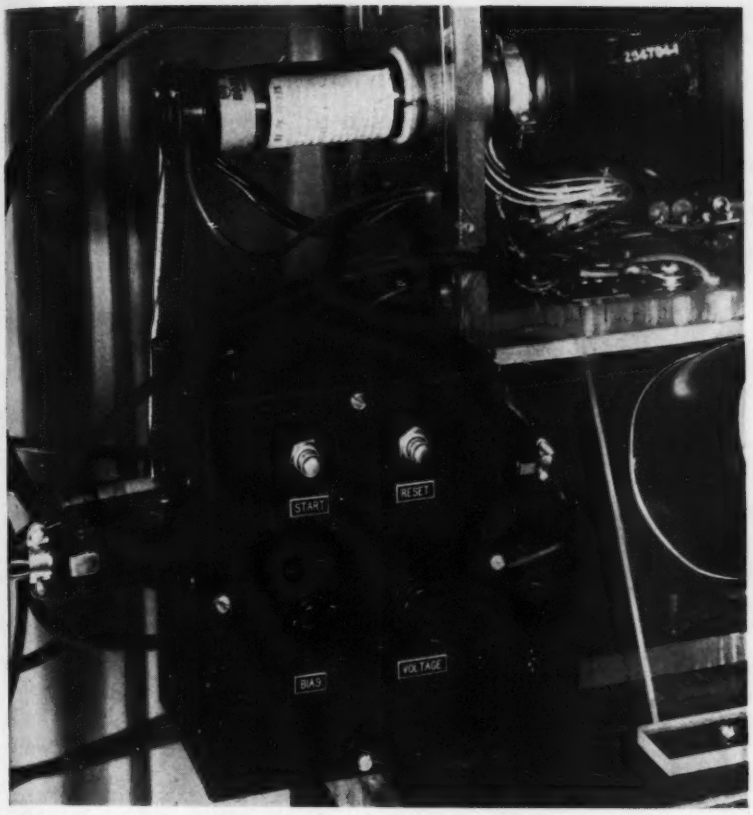

FIG. 3—Front panel of electronic timer. Start button initiates exposure; reset button makes timer circuits operate for subsequent exposure; bias control establishes correct pretriggering conditions for thyratrons; and voltage control adjusts picture radiance

housing is 5 in. wide, 6 in. high and 4 in. deep.

Performance Checks

An easy way of checking the timer circuit is to examine, using an oscilloscope, the shape and duration of the voltage pulse applied to the cathode of the kinescope. A typical trace is shown in Fig. 4A. Retrace blanking pulses, which are shown as sharp vertical lines, provide convenient timing marks for determining the duration of the pulse at the kinescope cathode.

The downstroke of the 1/30-sec square-wave pulse should coincide with a given retrace blanking pulse. The upstroke should coincide with the next retrace blanking pulse. Line *MM'* on Fig. 4A represents the approximate potential level at which the kinescope is cut off; therefore, the shape of the voltage pulse above this level is of no practical importance.

Actual shape of the pulse is controlled by the shaping circuit made up of C_3 and R_5 (Fig. 2). Incorrect choice of values for these components leads to pulses of the type shown in Fig. 4B and 4C. Both types of distortion are undesirable since they give rise to appreciable vertical shading across the face of the kinescope.

Operating Considerations

Because electrical focusing of the kinescope is normally carried out at whatever beam current is required for a correct exposure, it is necessary to use a well-stabilized, high-voltage power supply with the timer to insure that flashed exposures remain in good electrical focus. When a 27-kv power supply stabilized to ±3 percent was used, photographic tests showed that the timer did not cause detectable defocusing of normal kinescope beam currents which range between 4 and 60 microamperes.

During experimentation, a 5ZP16 kinescope was operated under typical conditions. Voltage control R_2 was set to maintain the cathode of the kinescope at approximately 65 v above ground. When cut off, however, the cathode potential increases until it equals that of the 150 v supply. Since there are considerable variations in the operating characteristics of different kinescopes, the operating range of control R_2 may have to be changed. This can be accomplished by connecting a 20,000- to 50,000-ohm resistor in series with R_2. If this is done, the pulse shaping circuit made up of C_3 and R_5 must be adjusted to compensate for the change in circuit time constant.

Reference

(1) RCA. Instruction Book, "Television Photographic Monitor, Type TMP-20A," Fig. 12.

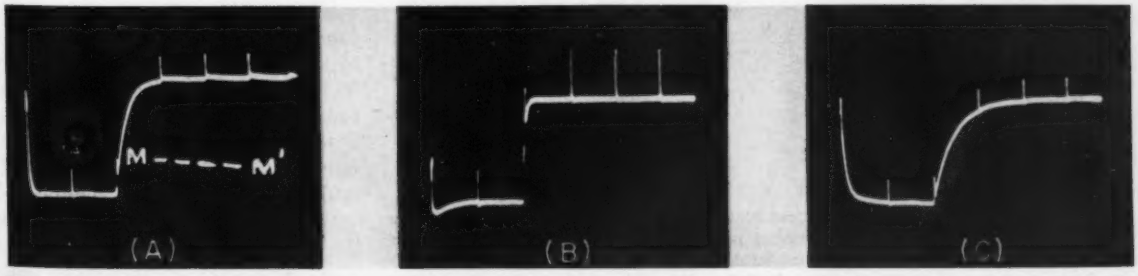

FIG. 4—Typical trace (A) of voltage pulse applied to cathode of crt. Distorted traces (B) and (C) occur when shaping circuit is incorrectly designed.

Simple, inexpensive triggered-gap switch accurately controls switching of single-pulse currents. Switch operates at voltages down to 1 kv and handles currents up to 5×10^5 amperes. Time jitter is about 0.1 μsec between successive pulses. Switch is applicable to surge-current generators, magnetron testing and light-pulse generation

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Low-Voltage Trigger

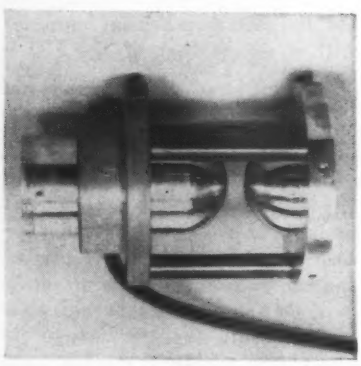
A SATISFACTORY METHOD of handling single pulse currents of 10^5 amperes and above has presented difficulties which this triggered-gap switch avoids.

The usual triggered-gap switch[1-3] is adequate in all respects, provided the voltage is above the corona voltage, approximately 15 kv, and provided the process is repeated with sufficient frequency, normally 1,000 pps. However, if the voltage is low and the switch is used in single shot operations, these gaps show unacceptable jitter.[4]

In other words, the time between application of the trigger and the firing of the gap varies.

Several arrangements tried at 10 kv showed delays varying from 5 to 200 μsec between successive shots. Where results are to be viewed on a cro, with a total trace time of 10 to 50 μsec, such delays are unacceptable.

The Lovotron, low-voltage Triggertron, operates at voltages as low as 1 kv for single shots and with a time jitter of about 0.1 μsec. It is simple, inexpensive to construct and not critical in adjustment.



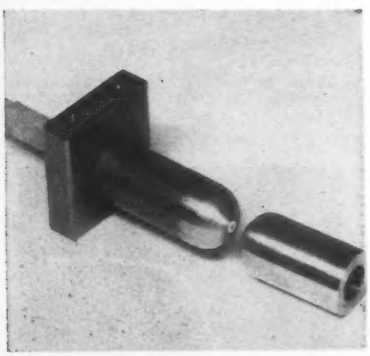
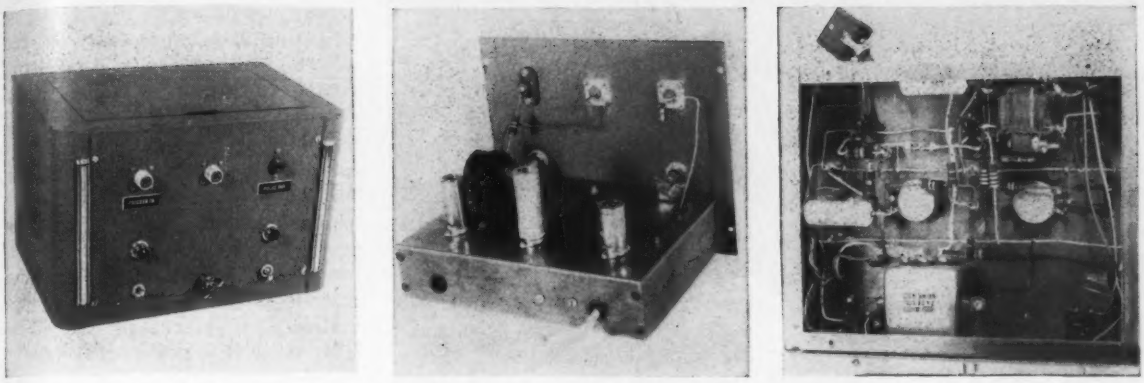


FIG. 1—Cross-sectional drawings with matching photographs show two tirggered-gap switches. In the earlier model (top) refractory metal inserts of molybdenum or tungsten wire were pressed into the tips to minimize erosion by the arc. The later model (bottom) proved satisfactory without the inserts. A Teflon sleeve is used around the trigger wire to prevent delays and irregularities from occuring

Triggered Gaps

The conventional triggered gap consists of a pair of electrodes, spaced far enough apart so that the applied voltage is insufficient to jump the gap. When it is desired to start flow of current, a trigger is introduced into the gap which causes it to break down. Various types of triggers have been used: Ions or electrons may be injected into the gap, a sudden voltage increase may be introduced to bridge the gap, or shock waves and ultraviolet light may be used. The first type, electron injection, was chosen



Front, rear and bottom views of the trigger generator show the physical layout of the components

Controls High Currents

for this particular application.

Triggered gaps are subject to three types of unreliability: preignition, irregular firing and delayed firing. Preignition, the easiest to control, is caused by too short a gap, or by electrons remaining in the gap. A properly designed gap allows sufficient spacing so that it will never fire without a trigger. In single-shot work, remaining electrons are not a problem.

Unless a gap is properly designed, then even when the spacing is great enough to prevent preignition, the firing will not occur every time it is triggered. This type of unreliability is referred to as irregularity.

The most difficult type of unreliability to overcome completely is delayed firing.[4] When this occurs, the gap fires, but at a delayed time after application of the trigger. This delay is particularly undesirable where results are to be recorded by photographing cro traces. Often these delays are long enough, 200 μsec or more, so the trace is complete before the gap fires, hence no record at all is obtained. Most of the development work was devoted to eliminate this delay.

The gap finally selected, a modification of the circuit described by Craggs, Haine and Meek,[2] has the same high current carrying capabilities of any triggered gap and low jitter, that allows an accurate scope trace to be observed.

In the original circuit (operation depended on corona or field distortion) an insulator especially designed to produce maximum corona (corona cup) was included. Since this unit is designed to operate below the corona voltage, no corona shield was included. Attempts to fire by field distortion do not work.

By increasing the trigger voltage, electrons are generated by the resulting spark and fire the gap. To make the spark occur between the switch electrodes, where it would break down the required gap, a Teflon sleeve was used around the end of the trigger wire. The spark then jumps to the cathode in the space between the main electrodes breaking down the gap.

The electrodes are made of copper and in the original model a refractory metal insert made of molybdenum or tungsten was pressed into the tips to minimize erosion by the arc. Later models, built without the insert, worked so well that the added complication was unnecessary. The hole for the trigger wire is bored through the hard inserts by electrosparking.[5]

Insulating pillars are made of linen base phenolic resin and the interior insulator is either Lava ceramic or Teflon.

The plastic sleeve around the trigger wire is particularly important. Without the sleeve, the triggering spark occurs back from the

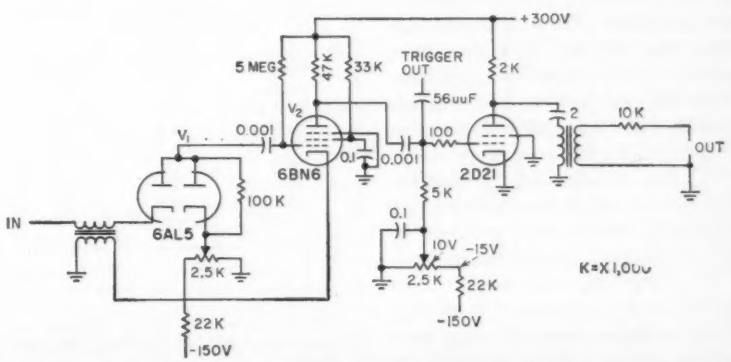


FIG. 2—The trigger generator circuit has a damped sine-wave output of sufficient amplitude to fire the gap. Pulse sharpener, V_1 and V_2 is included

Operator adjusts triggered-gap electrodes for proper triggering. In this experiment the energy of a large capacitor is discharged through a small piece of wire and the wire disintegrates in about 5 μsec.

surface of the main electrode and delays and irregularities occur. These difficulties become worse as the gap is used because the trigger hole becomes cratered. As this crater becomes deeper, the spark retreats back from the surface until it fails to fire the gap altogether.

The plastic tube lasts for 100 to 200 firings and is easily checked, since it becomes frayed on the end.

The great advantage of the Teflon sleeve lies in its consistency, which allows it to be pressed on the trigger wire, removing the possibility of the sleeve falling off when expanded by the heat of the discharge.

The plastic sleeve should be flush with the surface of the electrode and the trigger wire should project not more than 1/32 inch.

Polarities are important if delays are to be prevented. If polarities are changed, gap operation is unsatisfactory. The electrode carrying the trigger wire should be positive with respect to the hemispherical electrode. The trigger wire should go positive during the triggering pulse.

The gap is subjected to considerable mechanical stress during firing and rigid construction is essential for satisfactory performance.

Since some of the metal of the gap electrodes is vaporized at each firing, surfaces near the gap soon become coated with a metallic deposit. Insulating supports of the electrodes must be wiped clean frequently or the deposit will cause the gap to preignite. Wiping the electrodes, every third time the gap is fired, with a clean, lint-free cloth, wet with an organic solvent, prevents any trouble from this source.

Apparently photoelectrons play some part in the operation of the switch. On several occasions, difficulties were encountered late in the day as the light in the laboratory faded. These failures disappeared when the lights were turned on. A commercial reflector-type light bulb (150 w) is mounted about six feet from the apparatus so that the short electrode may be illuminated when needed.

The gap electrodes are spaced exactly by slots and Allen set screws, as shown in Fig. 1. Close adjustment is unnecessary as the switch has considerable gap-setting latitude as shown in Table 1. No precise statement of maximum and minimum voltages can be made because the conditions of the cathode surface have considerable influence on these values. Even low values of current such as would be used for radar operation, affect the cathode surface.[8] The range of operation is greater than the variation, hence it is not a problem.

Table 1—Effect of Gap Setting on Voltage Range

Gap Length (inches)	Minimum Voltage (kv)	Maximum Voltage (kv)
0.25	5	11
0.2	3.5	10
0.15	3.5	10
0.1	2	9
0.075	1	7
0.05	0.9	5
0.035	irregular	4

Minimum voltage is the lowest voltage at which the gap may be triggered 90 per cent of the time. Maximum voltage is the voltage at which the gap breaks down without trigger

Trigger Generator

The trigger generator has little influence on the behavior of the gap provided it produces a trigger of sufficient voltage (15 kv) and of sufficiently fast rise time (0.1 μsec).

The trigger generator circuit is shown in Fig. 2. The output is a damped sine wave of sufficient amplitude to fire the gap and of about 1/10-μsec duration. Since the pulse used to trigger the switch circuit has a slow rise time, a pulse sharpener V_1 and V_2 is included. This is unnecessary if a suitable trigger pulse is available.

The trigger-out connection is included to make a low voltage available that is timed to the switch. The 10,000-ohm resistor protects the transformer from any backup from the high current circuit.

The device may be used for any operation in which large currents must be accurately controlled. For example, it was used in an investigation of the exploding wire.[9-10] In this experiment the energy in a large capacitor is discharged through a small piece of wire. The wire disintegrates in five μsec.

The authors thank M. O'Day, Chief of the Advanced Research Laboratory.

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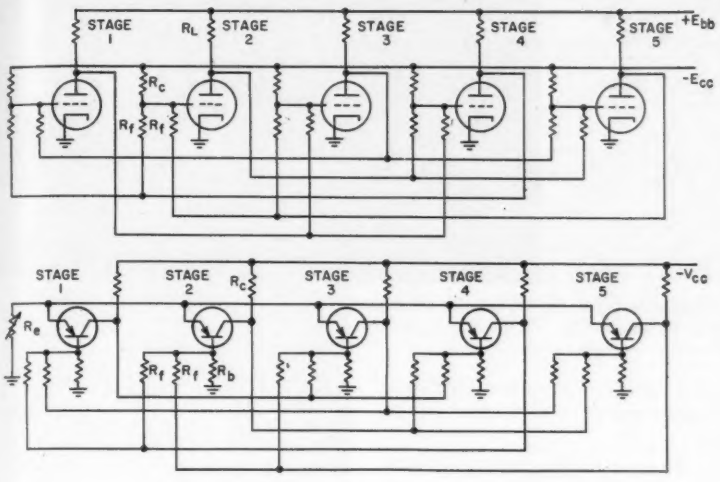

FIG. 1—Basic five-stage ring circuits with connections in accordance with Table I

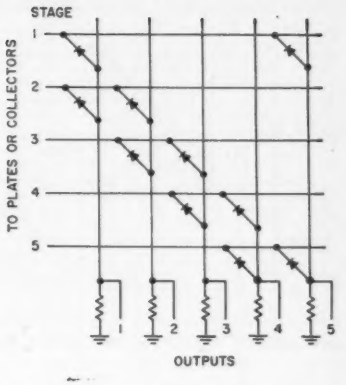

FIG. 2—Diode matrix for rings of five, such as those shown in Fig. 1

Ring Counter Has Increased Count Capacity

By having more than one stage ON in transistor or electron tube counter, more stages may be held OFF and maximum number of stages in ring may be increased from five to 12. New circuit offers savings in number of circuit components required compared to conventional rings of same number of stages

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CONVENTIONAL RING COUNTERS have one ON stage to hold off the other stages through an arrangement of feedback resistors. Instead of permitting only one stage in the ring to be on, the counter[1] to be described differs in that a recognizable sequence of ON and OFF stages is allowed; the count is indicated by the location of this pattern of ON and OFF stages which is stepped one stage along the ring at each count pulse.

The counter requires N tubes or transistors for a count of N. In both the new and conventional counters, the number of stages in a single ring is limited by the number of tubes or transistors that an ON stage can hold off.

By having more than one stage in the ring on, more stages may be held off and larger rings constructed. Rings of five are about the practical upper limit for the conventional ring while a ring of 13 represents the corresponding upper limit for the new counter.

In designing the ring counter, one restriction is that the pattern of ON and OFF stages must be recognizable. For example, a ring of eight having a sequence of three adjacent stages on and five stages off would be satisfactory, but a sequence of alternate ON and OFF stages would not be satisfactory since it would be impossible to determine the count by the location of this sequence.

Another restriction is that the ring must be designed so that only one recognizable sequence of ON and OFF stages may exist. For example, if an attempt is made to design a ring of eight using two

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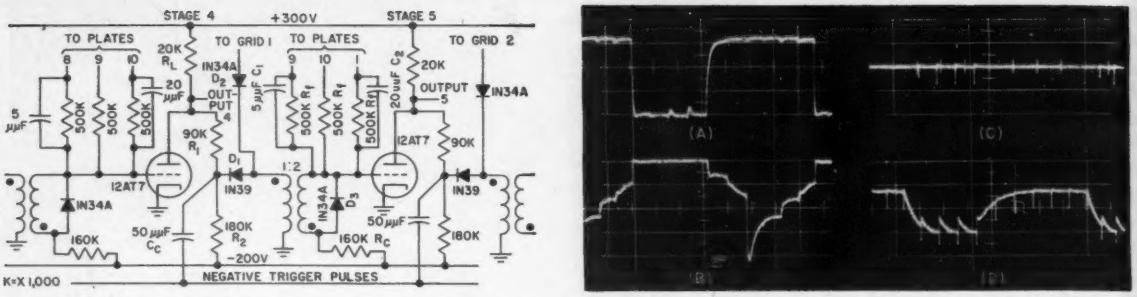

FIG. 3—Partial diagram of ring of 10 is wired according to Table II. Waveforms show plate voltage (A), grid voltage (B), pulse transformer primary voltage (C) and voltage at junction of R_1 and R_2 (D)

feedback resistors per stage (three are required) for a pattern of three ON stages and five OFF stages, it will be found that this pattern exists along with another consisting of alternate ON and OFF stages. A ring of this design would be erratic as any disturbance of the circuit would likely cause the mode of operation to change.

A similar situation occurs if a ring of eight using three feedback resistors per stage is designed to operate with two ON stages, instead of three, and six OFF stages. In this case, the circuit may be divided into two rings of four.

Wiring Schemes

Table I shows the wiring scheme for five and an eight-stage ring. The top row of numbers label the stages in the ring and the numbers in the columns below indicate the stages having plate circuits connected through feedback resistors to the grid of the tube heading the column (for transistors substitute base for grid; collector for plate).

For example, in the ring of eight stages, the grid of stage 1 is connected through feedback resistors to the plates of stages 4, 5, and 6. An ON stage holds off the stages having grids connected through feedback resistors to the ON stage plate.

Table I—Wiring Scheme for Rings of 5 and 8

Ring of 5

1	2	3	4	5
4	5	1	2	3
3	4	5	1	2

Ring of 8

1	2	3	4	5	6	7	8
6	7	8	1	2	3	4	5
5	6	7	8	1	2	3	4
4	5	6	7	8	1	2	3

In the ring of five there are two adjacent stages on and the rest off. The ring of eight is similar except that three feedback resistors per stage are required and each ON stage controls three OFF stages; three adjacent are ON stages and the rest off. The number of ON stages is not necessarily equal to the number of feedback resistors.

Figure 1 illustrates basic circuits of rings of five; feedback resistors are labelled R_f.

In some applications it may be desirable to decode the pattern in the ring to the conventional count indication with the output appearing at one lead at a time. This may be accomplished with a diode matrix having two diodes per stage, forming a product circuit.

Figure 2 shows a matrix for a ring of five (for *pnp* transistors diode polarities are reversed). If stages 1 and 2 of the counter are on, a signal appears at output 1. The next count causes stages 2 and 3 to be on and a signal to appear at output 2 and so on.

Design Theory

Assuming the rings will be wired so that ON stages occur in a consecutive group, let N equal total number of stages in the ring, R the number of feedback resistors per stage and S the number of ON stages.

For only one pattern of ON and OFF stages to occur, the first and last ON stages must together control all the OFF stages. This restriction requires that the maximum number of OFF stages $= 2R$ with $R > 1$.

Because an ON stage plate can connect only to an OFF stage grid and connections are made as in Table I, to eliminate rings made up of smaller independent rings, the number of OFF stages $= S + R - 1$. The total number of stages is this

$$N = 2S + R - 1 \qquad (1)$$

Equation 1 shows that an odd number of feedback resistors is required for an even number of stages. The converse also is true.

Table II—Wiring Scheme for Vacuum-Tube Ring of 10 with Compensating Capacitors and Gating Circuit

1	2	3	4	5	6	7	8	9	10	Stage Number
7	8	9	10	1	2	3	4	5	6	R_f
6	7	8	9	10	1	2	3	4	5	
5	6	7	8	9	10	1	2	3	4	
5	6	7	8	9	10	1	2	3	4	C_1
7	8	9	10	1	2	3	4	5	6	C_2
4	5	6	7	8	9	10	1	2	3	D_2

From the above equations, the maximum number of stages for a given number of feedback resistors per stage is found to be

$$N_{max} = 3R + 1 \qquad (R > 1) \qquad (2)$$

For a ring of eight, an odd number of feedback resistors per stage are required. Equation 2 shows that three feedback resistors make possible a ring of 10; therefore, three feedback resistors are required. Substituting $N = 8$ and $R = 3$ in Eq. 2, S equals three.

The plate of a given stage is connected through feedback resistors to the grids of three successive stages starting with the Sth stage after the one in consideration. This

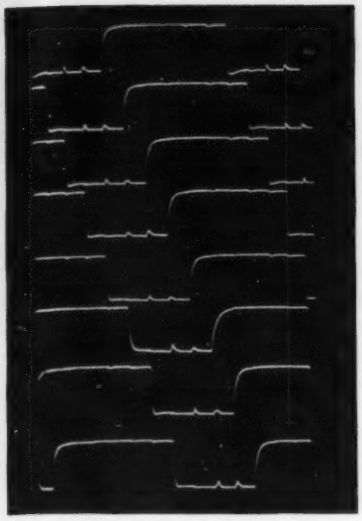

FIG. 4—Plate waveforms at eight consecutive stages in ring of Fig. 3

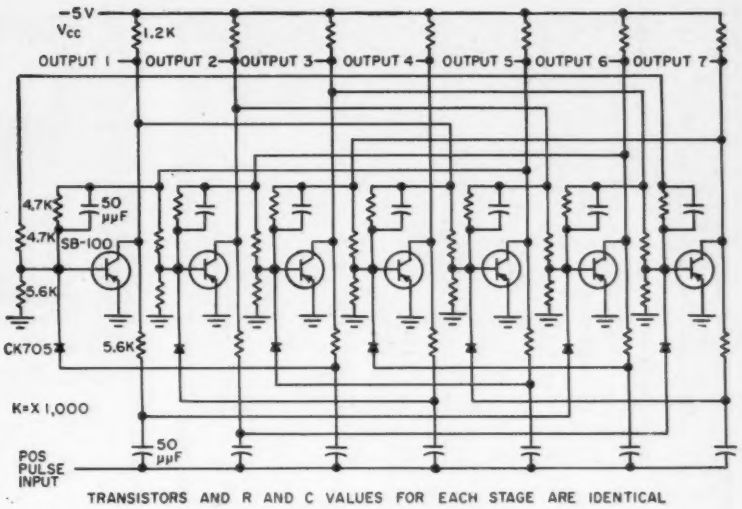

FIG. 5—Seven-stage transistor ring counts megacycle pulses

gives the wiring scheme shown in Table I.

Equations 1 and 2 show that by using $R = 2$ and $R = 3$, rings with a maximum of 10 stages may be made, except for the ring of nine which requires four feedback resistors per stage. Using one feedback resistor per stage yields a flip-flop or a ring of two.

Rings requiring four feedback resistors per stage, such as rings of nine, 11, 13, represent the upper limit of this type of counter corresponding to the conventional ring of five where one ON stage holds four stages off and four feedback resistors per stage are used.

If it were possible to construct a ring of 10 in the conventional way, with one ON stage and nine OFF, nine feedback resistors per stage or a total of 90 feedback resistors would be required. The counter makes possible a ring of 10 having three feedback resistors per stage for a total of 30. A further advantage is that the ring of 10 obtained this way is no more difficult to design than the conventional ring of four since in both cases an ON stage controls three OFF stages.

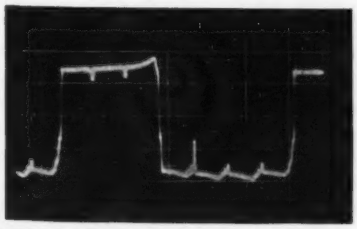

FIG. 6—Collector voltage waveform in transistor ring of Fig. 5 counting pulses at a rate of 1 mc

Experimental Models

Several experimental counters were constructed. In designing these counters it is necessary that a tube or transistor having a grid or base connected to an ON stage be held off even though connections are also made to other OFF stages. This problem is identical to that of the conventional ring counter with an ON stage holding the remainder off; rings requiring two and three feedback resistors per stage correspond to conventional rings of three and four respectively.

Figure 3 shows a simplified partial diagram of an electron-tube ring of 10 following the wiring scheme of Table II. This table is similar to Table I except that connections of C_1 and C_2 and D_3 are also shown. The gating circuits function to shift the pattern of ON and OFF stages one stage along the ring at each trigger pulse.

The gates are enabled by ON stages. A negative trigger to an enabled gate passes through diode D_1 to the associated pulse transformer to appear as a positive pulse at the grid of the following stage, turning it on if not on already. At the same time a negative pulse is applied through diode D_2 to the grid of the stage indicated, turning that stage off, if not off at the time. The result is that the group of four ON stages is moved one stage along the ring.

Capacitors C_1 and C_2 speed up the switching process and D_3 damps the pulse transformer.

Figure 3 also shows waveforms at various points in the electron-tube ring of 10. Figure 4 illustrates the shifting of the pattern in the counter along the ring. The waveforms were taken with the counter operating with 235-kc count pulses. The time constants of the gating circuits limit the counting rate to about 240 kc. A circuit of this type could be designed to operate at a megacycle rate with components that give faster time constants.

A seven-stage counter using surface-barrier transistors is shown in Fig. 5.

The waveform at one of the collectors when counting megacycle pulses is shown in Fig. 6. The gates function to turn off the last stage in the group of ON stages upon application of a trigger with the coupling capacitors assisting in switching on the stage ahead of the group.

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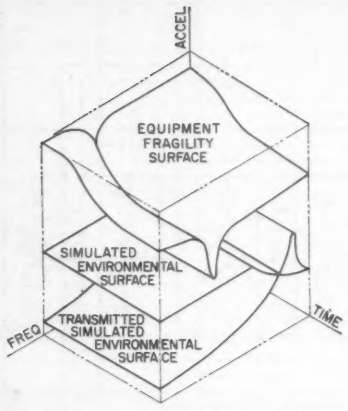

FIG. 1—Concept of equipment-fragility and simulated environmental surfaces

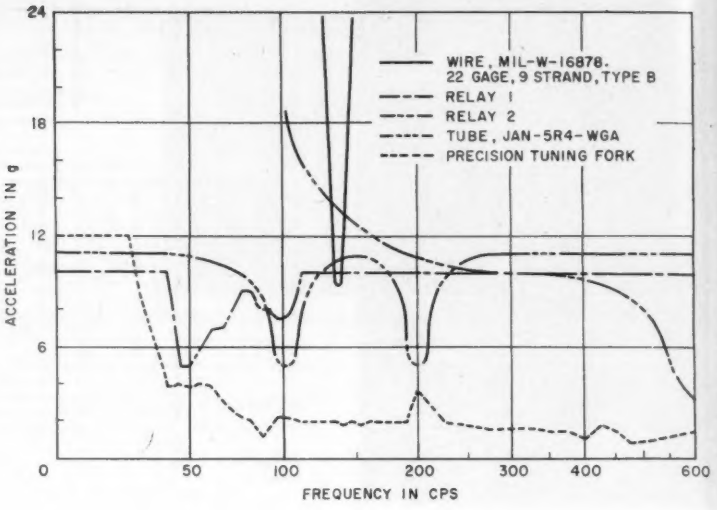

FIG. 2—Superposition of fragility levels of tuning fork and several components

Preventing Equipment

Efficient vibration-resistant designs are achieved without reliance upon trial-and-error construction of prototypes. A simulated vibration environment is assumed and its transmission through isolators is plotted and adjusted for practical considerations. A fragility curve is developed for each component type and a composite characteristic derived by superposition. Performance comparisons between beefed-up and resonance-damped chassis are given

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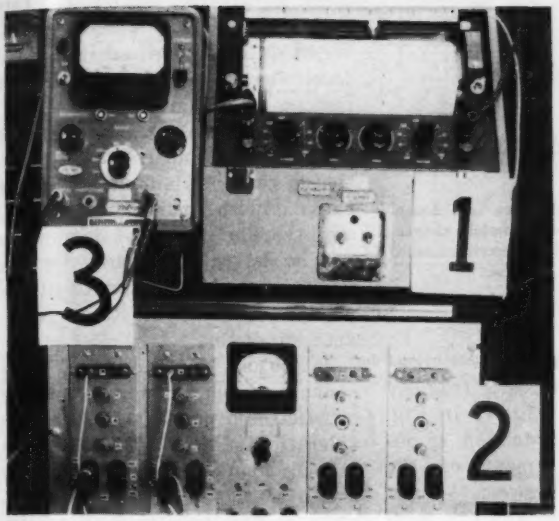
FAILURE OR MALFUNCTION of electronic equipment in its vibration environment is one of the least desirable occurrences upon completion of a design. Prediction of vibration-resistance limits of equipment in advance of laboratory or field tests is presently at a low confidence level. Newer methods have been introduced, however, which are supported by the views of many shock and vibration investigators.

Minimum requirements before an electronic package suited to a vibration environment can be designed include sufficient description of the environment and knowledge of equipment fragility. Then a composite fragility curve of the components of a new equipment is developed and compared to the simulated vibration environment and to the transmitted simulated vibration environment.

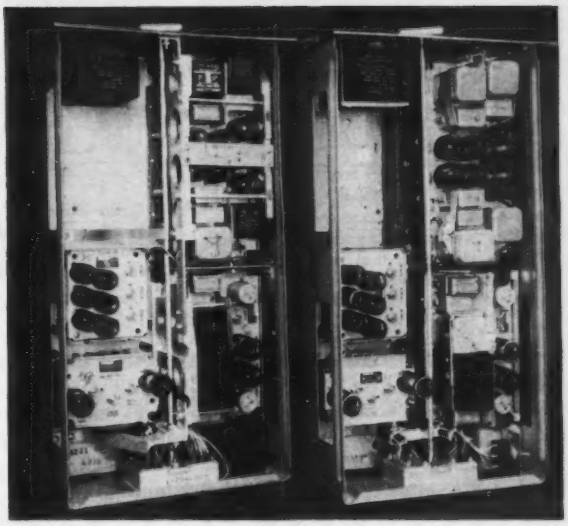
This transmitted test environment is described as that transmitted to a rigid body through an insolation system. Adjustment of the composite fragility curve is next and treatment of mechanical resonances completes the considerations involved in the preliminary design.

The concept of a fragility surface[1, 2] for an equipment is illustrated uppermost in Fig. 1. This surface is obtained from a large collection of minimum vibration amplitudes, as functions of frequency and time, which will cause equipment failure. In determining the surface, reference is made to the attachment point of the equipment to its support. If resilient mounts are used the reference is the point of attachment to them.

The equipment mechanical im-



Transmissibility measurements require X-Y recorder (1), ratio plotter (2) and frequency meter (3)



Two modes of packaging for identical circuitry are compared side-by-side. Left chassis is beefed-up, that at right, resonance-damped

Vibration Failures

pedance and circuit characteristics are combined in this fragility determination and can therefore be determined only well into the design stage. Dangerously low fragility levels due to sensitive components or poor chassis impedance can lead to delays, and at best the level obtained will be valid only for the particular equipment.

But standardization would be gained if at this point the fragility determination were shifted from that for the equipment to those for the components[3]. Generally applicable fragility curves can be acquired singly through laboratory testing of components, parts and processes. These fragility levels represent the probability failure below minimum reliability requirements.

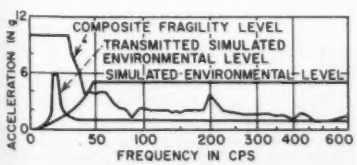


FIG. 3—Effect of primary isolation on transmitted simulated environmental level

Where variance in operating characteristics affects fragility, families of curves are required. Standard fragility tests are needed for rapid accumulation and comparison of data. Problems of complex wave or sinusoidal excitation and three or six degrees of freedom must be resolved to attain standardization.

Component Deficiencies

Information from fragility tests has the secondary effect of disclosing deficiencies in component designs[4]. In vibration tests on guidance equipment of the Snark missile, significant improvements in fragility were often easily made upon furnished components. Fragility curves readily permit selection of vibration-resistant components in the initial design stages.

The fragility level for a precision tuning fork is shown by one of the curves in Fig. 2. The curve is a composite of vibration tests performed in the three principal axes of the unit. Malfunction criteria were established at 0.002 percent frequency change.

By considering component operating characteristics imposed by equipment requirements, fragility curves for components, parts and processes may be superimposed to give a composite curve representing the combination of sensitive units for the proposed equipment. Numerous cases will arise where special fragility tests will be required because of unique operating requirements or nonstandard parts.

Curve Superposition

The superposition method is shown in Fig. 2, where four components and one process represent the sensitive items of a hypothetical electronic equipment. All component fragility curves must be based upon standardized tests to achieve a truly composite curve. The 5R4 tube was tested in the same manner as the tuning fork with element resonances and emission deterioration as malfunction criteria. The fragility curve for relay 1 was secured from a private source, and that for relay 2 was published previously[5].

The fragility curve[6, 7] for the wire is dependent upon manufacturing process control. Three dis-

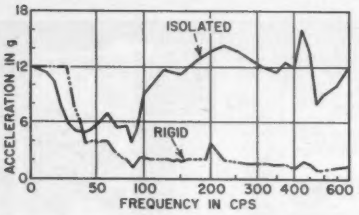


FIG. 4—Effect of secondary isolation on fragility level of tuning fork, whose mass is much less than that of equipment, is shown in the curves

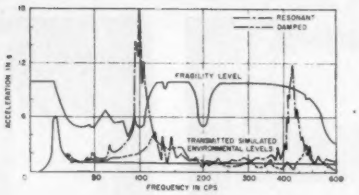


FIG. 5—Effects of resonance and damping of ruggedized sheet-metal chassis upon transmitted simulated environmental level. Results are not optimum

tinct types of environmental tests were conducted. Wide-angle, slow-bend tests simulate wire flexing in assembly and maintenance. Small angle, moderate-frequency bend tests simulate wire motion due to relative movement of two chassis points at mechanical resonance. The third type comprises single-wire vibration tests. Variables of gage, number of strands and type were studied to select the optimum wire and best installation practice. A fourth variable, the *K* factor, is defined as the bare-wire length from the end of the solder fillet at the wire termination to the edge of the wire insulation. Optimum installation practice for wire or chassis resonance has a limit of 2-in. spans with ¼-in. to ⅜-in. slack as maximum unsupported lengths. Factor *K* is optimum at 0.125 in.

Curve Comparison

The composite component fragility level of Fig. 3 is drawn from the minimum amplitude levels of the items in Fig. 2. Comparison of this composite curve to the curve of the simulated vibration environment readily predicts equipment malfunction. Vibration insolators[8] yield some improvement in malfunction tendency where the transmitted simulated environment level is constant from mid to high frequencies. This mean data originates from a large isolated rack structure where multisource inputs and impedance characteristics affect isolator attenuation.

Solution of this marginal situation can be seen upon examination of the superposition graph of Fig. 2 where the tuning fork dominates the composite fragility level. Changing to a more rugged tuning fork or isolating the fork will drastically alter the composite fragility level, as shown in Fig. 4. In Fig. 5 the degree of protection is obtained by measurement of the minimum distance between the new curve of composite fragility level and those of transmitted simulated environment levels.

Simulated Environment

The equipment rack, insolation system and chassis are considered part of the environment. The effects of multisource inputs, rack resonances and flight vibration are illustrated in the transmitted simulated vibration environment of Fig. 3 and 5. In accordance with Fig. 5, design work could proceed from this point, provided the chassis could be considered a rigid body for the frequencies of interest[9,10,11].

The advantages of the sheet-metal chassis in weight reduction, improved access and ease of design change are offset by the serious resonance problems within the frequency range of interest, as shown in the resonance curve of Fig. 5. This display discloses highly probable malfunction of the equipment despite extensive stiffening of the sheet metal. This chassis is quite adequate for other types of fragility curves, particularly when detuning and decoupling techniques can be applied[12]. These depend upon resonant frequency and amplification determination, however, which for complex structures are difficult to predict and are more easily obtained by testing prototypes.

Another approach is to apply structural dampers to the sheet-metal chassis. The resonant and damped curves of Fig. 5 are recorded from identical chassis, except that experimental dampers replace structural stiffening. This technique is still under development, so the damped environmental level shown in Fig. 5 does not indicate optimum results.

The principle advantages found in the use of dampers are the retention of relatively simple, producible chassis with maintenance accessibility. The degree of damping is best determined by energy methods[13] and retention of simple chassis designs facilitates resonance prediction[14, 15].

Vibration test equipment uses shakers driven by motor-generator or electronic power supplies. Consideration of the practicality of an overall component fragility curve suited to the circuit requirements of an equipment requires intensive study. Development and application of dampers to structures is a challenging area of investigation.

The authors appreciate the encouragement and support of C. H. Swan and other members of the Nortronics technical staff, C. T. Molloy of Lockheed Aircraft and H. Himelblau of North American Aviation.

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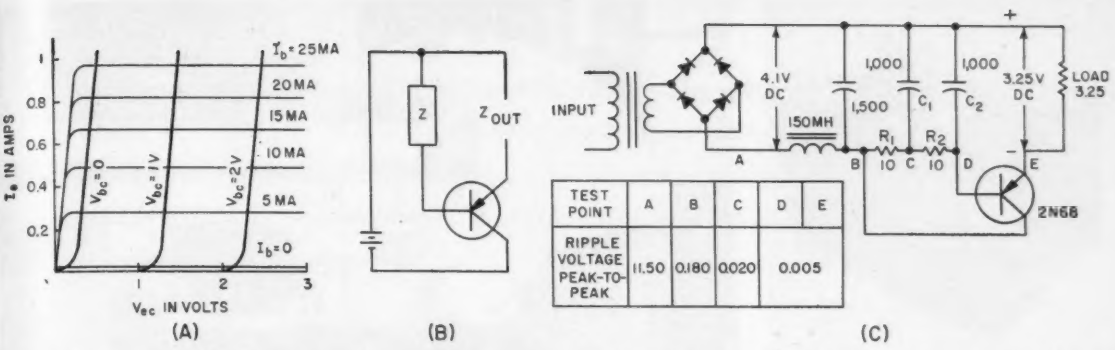

FIG. 1—Output circuit characteristic (A) and basic circuit configuration (B) of junction transistor common collector amplifier. Circuit of transistor ripple filter (C) provides one ampere of highly smoothed d-c from a bridge rectifier. Filter capacitance required is 3,500μf

Transistor Filters Ripple

Junction transistor provides improved smoothing performance in low-voltage d-c power supply. Use of smaller capacitors and chokes in filter network affords economy in space, weight and component cost

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THE ABILITY OF JUNCTION transistors to operate as impedance transformers makes them efficient for use in d-c smoothing-circuit applications by improving filtering performance and by eliminating the need for large capacitors and chokes in the power supply. In the circuit presented, the transistor provides one ampere of highly smoothed d-c from a bridge rectifier. Size of the smoothing capacitance necessary to obtain adequate performance is 3,500 μf which is about 60 times less than ordinarily required.

Basic Principles

Figure 1A shows that the output impedance of a junction transistor in grounded-collector connection is a function of the impedance in the base circuit. It is possible therefore to control the voltage conditions that prevail in the low-impedance emitter circuit by controlling the base circuit at a substantially higher impedance level.

In Fig. 1B the basic circuit configuration is shown with an impedance Z in the base-collector path. The output impedance in practical application for such a configuration can be expressed as:

$$Z_{out} \cong Z\ (1 - \alpha)$$

With α approaching unity, the output impedance becomes extremely small and capacitance C, connected in the base circuit, will therefore have the same effect as a capacitance $C/(1 - \alpha)$ in the load circuit.

Ripple Filtering

Shown in Fig. 1C is the circuit of the transistor ripple filter. The voltage at the output of the full-wave bridge rectifier is 4.1 volts d-c. A ripple voltage of 0.18 volt, peak-to-peak, appears across the first filter capacitor. Substantial ripple reduction is obtained with the load across the filter capacitor through the collector-emitter path of the junction transistor. Base current, which amounts to only a small fraction of the emitter current, is provided by a separate filter consisting of C_1, R_1, and C_2, R_2. With a 3.25-ohm load supplied with 1 ampere d-c, the residual peak-to-peak ripple current and voltage in the load is 0.0015 ampere and 0.005 volt, respectively. Total capacitance used for smoothing amounted to 3,500 μf.

Using the same 150-mh choke and 3,500-μf capacitors and omitting the transistor, peak-to-peak ripple amounts to 0.056 volt at 0.017 ampere, with 1 ampere of d-c flowing. Increasing the capacitance by 40,000 μf reduces the peak-to-peak ripple to 0.015 volt at 0.0046 ampere. To obtain performance equal to that using the transistor would have necessitated the use of a larger choke or a capacitance equal to approximately 200,000 μf.

The circuit described was developed to provide an exceptionally well smoothed current supply for the calibration of d-c meters up to 1 ampere.

The authors thank the directors of Ferguson Radio Corporation, Ltd., for permission to publish this article.

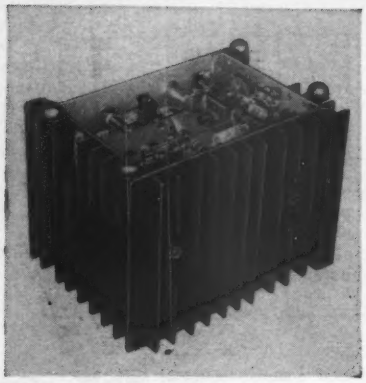
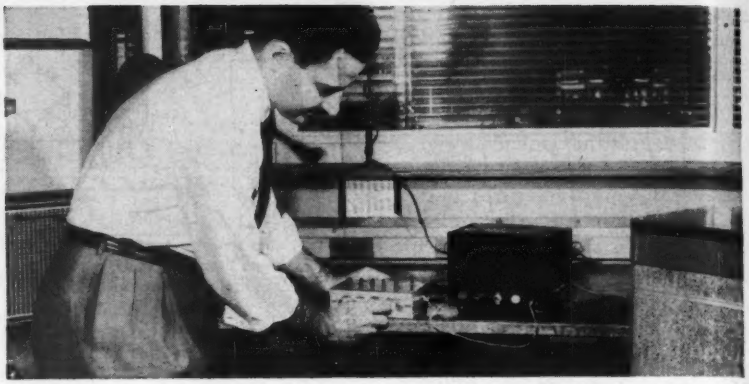


Fig. 1. Ribbed chassis provides both convection and radiation cooling



Preamplifier is adjusted in typical set up of record changer, preamplifier, power amplifier and speaker

Designing Transistor A

DESIGN techniques different from those used in low-power amplifiers are necessary for high-power transistor audio amplifiers. Both thermal and electrical limitations impose an upper limit on the power handling capabilities of the transistor. When transistors operate at high junction temperatures, the thermal considerations become important. For good circuit performance the chassis or other cooling facility employed must be capable of removing the heat generated by the transistor. Maintaining both a good thermal path from junction to air and a relatively stable d-c operating point over the intended temperature range will provide the necessary circuit stability.

Quasicomplementary Symmetry

The convection-cooled quasicomplementary symmetry amplifier[1] shown in Fig. 1 is designed to operate over a temperature range of −10 C to +50 C. The amplifier has outside dimensions of 8½ by 6½ by 6½ inches and weighs about 10 pounds. The circuit of Fig. 2, consists of three stages: a *pnp* class-A driver stage; a complementary transistor pair, which acts as a phase splitter; and a power output stage, consisting of two *pnp* transistors in single ended push-pull operation, capacitance-coupled to the load. The last two stages operate as class-B amplifiers.

Transistors Q_2 and Q_4 operate as common-collector amplifiers. When these transistors are conducting, the output current is $\beta_2\beta_1$ times the current supplied by the first stage, where β_2 and β_4 are the effective current gains of the phase splitter and output stages. Similarly, the output current when Q_3 and Q_5 conduct is $\beta_3\beta_5$ times the current supplied by the first stage, where β_3 and β_5 are the effective current gains of the phase splitter and output stages. If $\beta_2\beta_4 = \beta_3\beta_5$, the input resistance presented to the first stage is equal to $\beta_2\beta_4 R_L$, and the circuit is in balanced operation.

Output Stage

The output stage uses two 2N301A transistors connected in series with the d-c supply. For proper amplifier operation these transistors should possess certain characteristics.

One important property is that they have a thermal resistance from junction to case of less than 1.3 C/watt. Close thermal coupling to the chassis, achieved by mounting the transistor on a Mylar insulator coated with silicone oil, results in

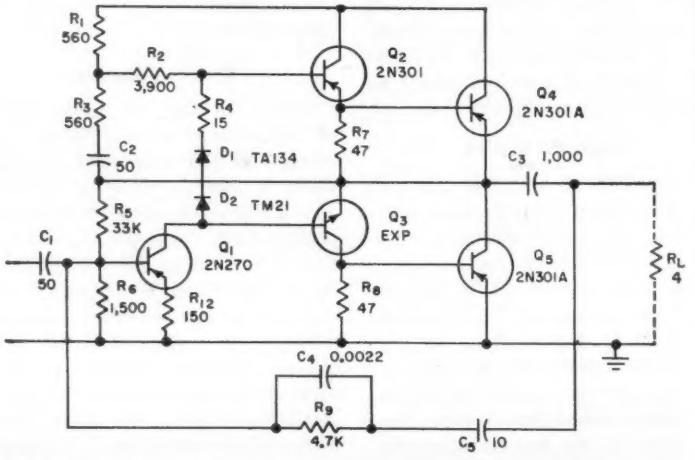


Fig. 2. Quasicomplementary symmetry amplifier delivers 45 w to 4-ohm load

High-power transistor audio amplifiers operate over ambient temperature range of −10 C to +50 C. Neither series type circuit nor quasicomplementary symmetry type circuit uses a driver or output transformer. Each amplifier can deliver 45w to a 4-ohm load. Output stages use *pnp* transistors exclusively

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A-F Power Amplifiers

a total thermal resistance from junction to air of about 3 C/watt. This resistance is sufficiently low so even the most severe condition of 10 to 12 watts dissipation from each transistor may be stably transferred to the air. The low chassis thermal resistance of about 1.6 C/watt is obtained both by convection and radiation cooling from the large surface area of the ribbed chassis configuration, as shown in Fig. 1. The amplifier chassis is painted a dull black to aid heat transfer by radiation.

Another important property of the output transistors is maximum collector-to-emitter breakdown voltage. This voltage depends on both the resistance connected between base and emitter and the junction temperature. It decreases when junction temperature is raised or emitter-base resistance increased (up to about 1,000 ohms).

Circuit Operation

The supply voltage is about 41 volts at full sine-wave power output. At peak signal swing the maximum inverse voltage applied to each output transistor is slightly less than the supply voltage. Under normal operating condition, a good d-c balance exists, and the center-point voltage at the collector of Q_5 is approximately equal to one-half the supply voltage.

The voltages across resistors R_7 and R_8, shown in Fig. 2 provide a small forward bias to the base-emitter junctions of Q_4 and Q_5. Forty-seven ohm resistors were chosen to minimize the nonlinear crossover region in the composite transfer characteristic of the class-B amplifier. They provide a bias of about 0.15 v at 25 C.

Bias voltage is ultimately determined by the voltage drops across R_6, D_1 and D_2. Diodes D_1 and D_2 are RCA TA-134 developmental temperature-compensating diodes. Forward voltage drop of the diodes decreases with increasing temperature and tends to hold the transistor emitter currents constant. The compensation is necessary since less forward base-emitter bias is required as junction temperature increases. For optimum temperature stability, three biasing diodes should be used.

A penalty must be paid to provide proper transistor bias and low distortion. The selection of small

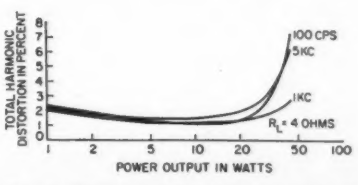

Fig. 3. Harmonic distortion increases at higher powers because beta falls off

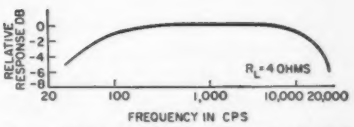

Fig. 4. Three db points are at 50 cps and 14 kc in amplifier response curve

value resistors for R_7 and R_8 results in a signal power loss of about 1 w at maximum power output. The loss occurs because the resistors are in shunt across the base-emitter junctions of the output transistors, which have a large-signal input impedance of approximately 20 ohms.

To minimize distortion the output transistors should possess a large-signal current gain of at least 25 at 4 amp of collector current. This is necessary since the peak collector current that flows in the transistors is between 4 and 5 amp. Because the output impedance of the driver stage is relatively low, variations in transconductance for the output stage are also important. Measurements show 2 to 1 variations may be tolerated.

Harmonic distortion of the amplifier at various power outputs is shown in Fig. 3. Distortion increases at higher power output because output transistor beta falls off at high collector currents. The reactance of C_3 gives an elliptical load line at low frequencies and as a result clipping occurs at high

power outputs. At higher frequencies, transistor phase shift causes nonlinearities and increases the distortion.

Complementary Phase Splitter

Transistor Q_2 shown in Fig. 2, is a *pnp* 2N301A and Q_3 is an experimental *npn* transistor. Both operate class B and split the phase of the incoming signal from Q_1. To allow the amplitude of the peak signal swing to approach the supply voltage, bootstrapping is applied by way of C_2 and R_8 across R_1. Without the bootstrap action the voltage drop in Q_2 and Q_4 limits the output voltage swing to a value less than the supply voltage causing unsymmetrical clipping at high outputs. Resistor R_3 was selected to give symmetrical clipping at maximum sine-wave power output. Under this condition, the maximum collector efficiency of the output stage was increased to about 70 percent at room temperature.

Frequency response of the amplifier is shown in Fig. 4. The 3-db points are about 50 cps and 14 kc. The relatively low beta cutoff frequencies of the power transistors used in the circuit limit the high-frequency response of the amplifier. Low-frequency response is limited primarily by the capacitor C_2.

Driver Stage

Transistor Q_1 2N270, a medium power unit, acts as a class-A driver. Since the biasing of following stages depends heavily on the direct current flowing in the collector of this transistor, temperature stability of this stage is important. The transistor is biased through resistor R_5 which is connected to the midpoint of the output stage. Both d-c and a-c negative feedback are provided through the resistor. The temperature stability of this stage is further increased by emitter-current stabilization provided by the emitter resistance R_{12} in conjunction with R_8.

Source impedance driving the amplifier should nominally be 500 or 600 ohms for proper performance. About 9 db of negative feedback is applied through R_9 around the entire amplifier to the base of Q_1. Capacitor C_4 is connected in parallel with R_9 to give a step response in the feedback loop for stability.

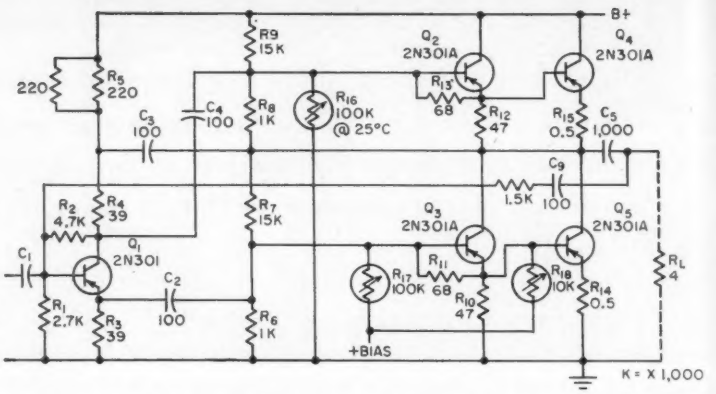

Fig. 5. Series amplifiers uses all transistors and requires no driver or output transformers

At full power output, power gain of the amplifier is about 41.8 db. The input impedance is about 200 ohms at 1,000 cps and the output impedance is about 1.6 ohms.

Series Amplifier

The series amplifier, shown in Fig. 5, uses all transistors of like conductivity and requires no driver or output transformers. It consists of a split-load phase inverter, capacitance coupled to a class-B common-collector driver. The driver is direct coupled to a class-B common-emitter power output stage. Driver and output stages are each in series for the d-c collector supply.

The amplifier also weighs about 10 pounds and is similar in size and physical layout to the quasicomplementary amplifier. It is convection-cooled, uses 2N301 and 2N301A transistors throughout, and delivers 45 w to a 4-ohm load.

Power Output Stage

A pair of 2N301A output transistors Q_4 and Q_5, operate in the common-emitter mode and are capacitance coupled to the load. The output stage operates class B; therefore, with oppositely phased voltages applied to their bases the a-c collector currents add in the load. Hence Q_4 and Q_5 are in series for the d-c collector supply and in parallel for the a-c signals.

Output transistors were selected for the same properties as transistors in the quasicomplementary amplifier. The reasonable linearity requirements of the transconductance characteristic for these power transistors shows the advantage of driving large-signal amplifiers from a low-impedance source, that is, a voltage source. Distortion increases when a high impedance source is used because of the relative nonlinearity of the current transfer characteristic caused by beta fall off. In the series circuit, a low output impedance common-collector driver stage provides a relatively low source impedance for transistors Q_4 and Q_5.

The resultant distortion characteristics are shown in Fig. 6. Distortion can be reduced at low frequencies by increasing the values of C_2, C_3, and C_4. The 0.5-ohm resistors in series with the emitter of each output transistor improve d-c circuit stabilization for the output stage and reduce distortion, but at the expense of a decrease in power gain and power output. Overall collector conversion efficiency, including the power lost in these resistors, is still about 65 percent at maximum power output.

Frequency response of the amplifier is shown in Fig. 7. The 3 db points are about 40 cps and 30 kc. High-frequency response which is limited by the beta-cutoff frequency of the transistors depends on the source impedance and the r_{bb}' of the transistors. The best frequency response for a common-emitter stage is obtained when it is driven from a low source impedance. It is also desirable, therefore that r_{bb}' be as low as possible. The 2N301 and 2N301A transistors used in the cir-

cuit have an r_{bb}' of about 20 or 30 ohms. The preceding stage is common collector and provides the desired low source impedance for the output stage. Low-frequency response is limited mainly by coupling capacitor C_8.

Series Driver Stage

The driver stage also uses a pair of 2N301A transistors connected as an emitter-follower. The stage operates class B and is direct-coupled to the output stage to eliminate a type of crossover distortion that occurs with capacitor coupling. Distortion arises because the coupling capacitor time constants for the charge and discharge paths are different during conduction and nonconduction. The difference causes a reverse d-c bias which is dependent upon the signal level, to be applied to the base-emitter junction. An increase in distortion results since the forward base-emitter bias applied to minimize crossover distortion is nullified.

In the driver stage, resistors R_{13} and R_{11} greatly reduced the crossover distortion caused by coupling capacitors C_2, C_3 and C_4. The resistors[2] linearize the input impedance presented to the phase inverter both during conduction and nonconduction. Tendency for a charge to develop on the capacitor and to produce crossover distortion is reduced by providing a low-impedance discharge path for the capacitors during nonconduction.

A 2N301 transistor Q_1 is used as a split-load phase inverter which feeds driver transistors Q_2 and Q_3. The stage operates class A and is biased at approximately 160 ma collector current with 35 v between the collector and emitter. This permits sufficient signal to be applied to the driver stage without introducing clipping at maximum power output. The transistor is closely coupled thermally to the ribbed chassis.

Resistors R_3 and R_4 provide a low source impedance for the driver transistors. The impedance presented by the upper half of the driver-output transistor combination is essentially equal to that presented by the lower half, since in each case there is a common-emitter stage preceded by a common-collector stage. Variations in the load impedance are reflected to the phase inverter in a similar manner for the upper and lower halves keeping the amplifier in balanced operation. A balanced output voltage is obtained by splitting the collector load and feeding the upper half of the amplifier from R_4.

Inherent negative feedback exists in the amplifier because of the phase splitter configuration, the common collector driver stage (100 percent negative voltage feedback)

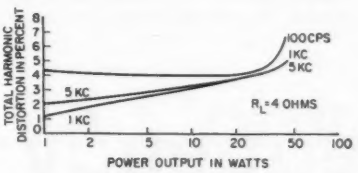

Fig. 6. Distortion can be reduced at low frequencies by increasing values of C_2, C_3 and C_4

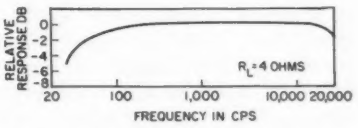

Fig. 7. Three db points are at 40 cps and 30 kc

and the unbypassed emitter resistors in the output stage. In addition about 8 db of negative feedback is applied through a 1,500-ohm resistor and capacitor C_9 around the entire amplifier. Bootstrapping similar to that used in the quasicomplementary amplifier is used to drive the upper half of the amplifier close to the collector supply voltage. The amplifier should be driven from a source having an impedance of about 500 to 600 ohms.

At full power output, the power gain of the series amplifier is about 30.6 db. Input impedance of the amplifier is about 113 ohms at 1,000 cps; output impedance, about 2.5 ohms.

Driver and Output Stage Bias

A small forward quiescent d-c base-emitter bias voltage is used to eliminate crossover distortion caused by the nonlinear transfer characteristics of transistors at low signal levels. Optimum bias voltage is obtained for the driver stages by the voltage divider action of resistors R_6 through R_{13}. The output transistor bias depends on the quiescent current of the driver stage and the voltage divider network. Quiescent current in the output stage is about 50 ma at room temperature.

As ambient temperature is increased, the operating points of the driver and output stage change, since both saturation current and input conductance increase.[3] The problem of d-c stabilization for the output stage is further complicated by the direct coupling of driver output stages. As temperature increases, the driver I_{co} increases, causing the forward voltage bias for the output stage to increase at the same time output transistor I_{co} is increasing and causes the quiescent current for the output stage to increase further. The one-half ohm resistors, R_{14} and R_{15} provide a negative current feedback that tends to keep output quiescent collector current constant.

In the common-collector driver stage, degenerative d-c feedback is obtained through resistors R_{10} and R_6 in the lower transistor, and resistors R_{12} and R_8 for the upper transistor. Thermistor compensation further stabilizes the d-c operating point of the output stage. The thermistors are mounted on the chassis near the output transistors to more closely compensate for the change in junction temperature rather than ambient temperature. Driver emitter current is kept constant by thermistors R_{16}, R_{17}, and R_{18} which provide a base-to-emitter voltage which decreases with temperature. A positive bias supply compensates the transistors at higher temperatures. It is actually necessary to apply a reverse bias to the base-emitter junction to maintain a relatively constant operating point at elevated temperatures.

This material was first presented at the Audio Engineering Society convention, New York, October, 1957.

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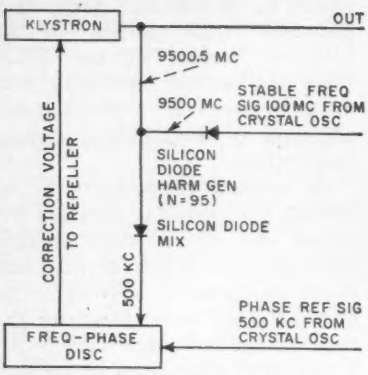

FIG. 1—Elements of phase-locking system used in frequency standard

X-band klystron phase-locked with quartz-crystal oscillator provides stability of few parts in 10^9 over entire day. One use is atmospheric phase-stability research

SHF Frequency Standard

FREQUENCY STABILIZATION of microwave signals is usually accomplished by reflex klystrons with cavity resonators or by direct multiplication from lower frequency quartz oscillators. A third approach uses a phase-locking technique[1] in which a small amount of microwave energy establishes the operating frequency of a relatively high-powered klystron.

The general method of operation is shown in Fig. 1. A crystal oscillator at 10 mc drives two vacuum-tube multipliers which deliver about 0.5 w at 100 mc. This is used to excite a silicon-diode harmonic generator[2] and produce small powers at frequencies in the X band. These harmonics are mixed with a small amount of the klystron output. If the klystron is operating at its nominal frequency, say 9,500.5 mc, one of the best frequencies at the mixer will be 500 kc. This signal is amplified and supplied to a phase discriminator, where it is compared with a second 500-kc signal from an auxiliary crystal oscillator.

Any phase shift in the klystron appears as a shift in the 500-kc beat, and the discriminator responds with an error voltage to the klystron's repeller. The klystron is thereby held to an average output frequency determined completely by the 10-mc and 500-kc crystals. Since the former is multiplied by about 1,000, its stability largely determines that of the klystron.

The circuit in Fig. 2 consists of a conventional amplifier with agc driving a discriminator. The refer-

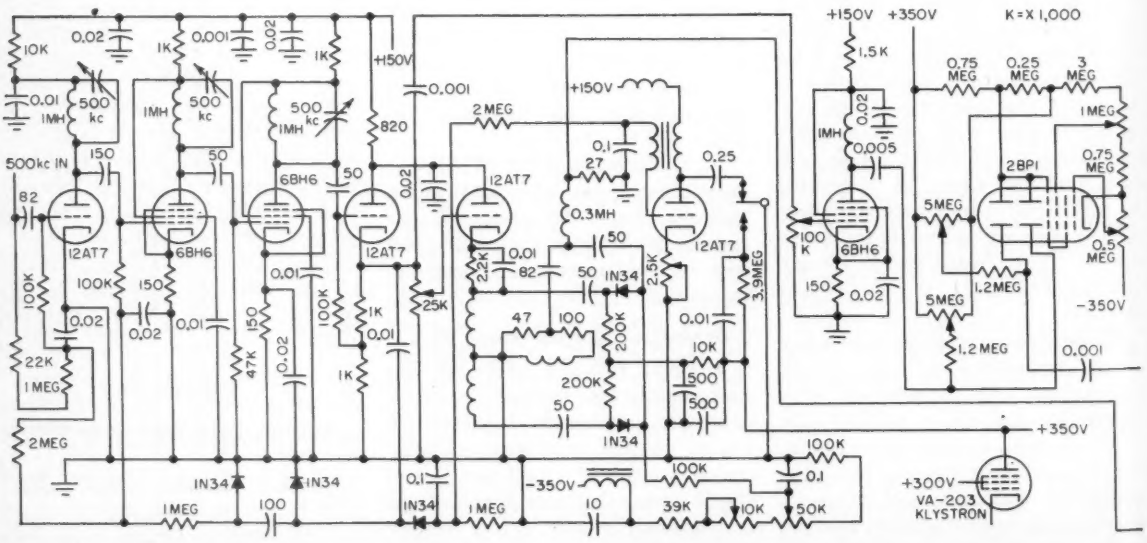

FIG. 2—Overall schematic of 500-kc phase-locking agc amplifier, discriminator and monitoring circuits, with auxiliary crystal

Compact microwave generator uses two quartz-crystal secondary standards to stabilize frequency of X-band reflex klystron. Sample of klystron output is mixed with first standard and beat is compared in phase discriminator with second standard. Difference frequency between first heterodyne and second standard develops correction voltage which is applied to klystron repeller

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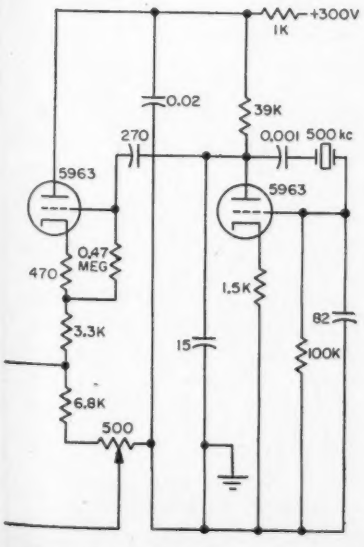
Uses Double Conversion

ence oscillator is a Pierce circuit. A reset circuit is provided for momentary interruptions which might cause the discriminator to lose control.

A 2-in. crt is used for observing the Lissajous figure formed between the reference-oscillator and i-f frequencies. The appearance of this figure is used for adjustment of error-signal time constant, hum neutralization and repeller bias. The normal appearance is a rather clean ellipse or circle.

A 1N23 silicon diode, mounted in a conventional waveguide holder, acts as a harmonic generator. A second 1N23 is a mixer and forms the beat between the harmonic energy and the klystron. A double waveguide T is used to join the two. The side arms of the T are about two wavelengths apart with a small screw halfway between. The location of the screw is such that essentially all the power from the klystron passes to the load. Adjusting the screw penetration provides control over the excitation of the mixer diode. A ferrite isolator follows the mixing system to reduce the effects of load changes on the mixing levels.



oscillator in modified Pierce arrangement

Using the 95th harmonic of the 100-mc signal and having the discriminator phased to operate the klystron above the incoming harmonic provides an operating frequency at 9,500.5 mc. By reversing the phase of the discriminator, the stable operating point for the klystron becomes 9,499.5 mc, thus giving a shift of 1 mc. A shift to a different harmonic, the 93rd or 94th, is also relatively straightforward. If the klystron is simply retuned until its output is in the vicinity of 9,400.5 mc, the system will stabilize to this frequency.

In addition to frequency shifts of 1 and 100 mc it is also practical in this system to shift 10 mc. This is the result of modulation which feeds through the vacuum-tube multipliers from the 10-mc oscillator to provide a 100-mc harmonic. By simply returning the klystron using the repeller bias, it is practical to lock the klystron to a frequency either 10 mc below or above any of the 100-mc harmonics. To utilize this feature, an ordinary commercial wavemeter is added to the plumbing to permit easy identification of the harmonic.

A further modification permits continuous frequency variation. The beat frequency signal from the diode mixer is fed into a conventional superheterodyne receiver and the phase-lock discriminator is designed to operate at the receiver i-f. The control loop now requires the klystron frequency to be such that, when its output is mixed with the harmonic of the secondary standard, the resulting beat equals the frequency to which the receiver is tuned. Klystron stability is now dependent upon that of the receiver local oscillator. A communications receiver might be expected to permit stability of the order of 10 cps (about 1 part in 10^9 at X band) over periods of several minutes and perhaps 1 part in 10^8 over periods of hours.

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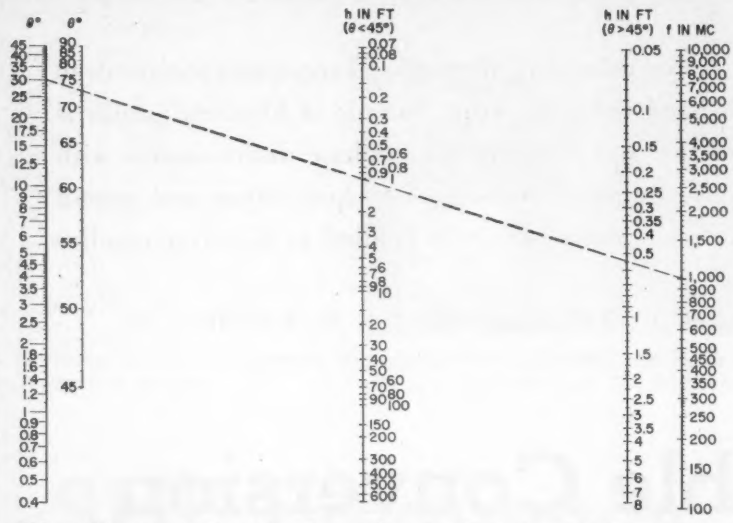

FIG. 1—Nomograph gives elevation angles of nulls in terms of frequency f and ground antenna height h

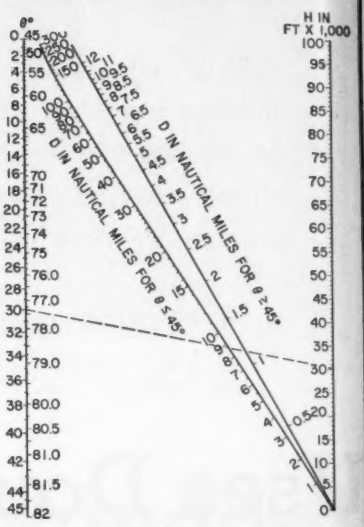

FIG. 2—Nomograph gives distance D from antenna to null at altitude H

Antenna Null Nomograph

Two straightedge settings give directly the distance in nautical miles from antenna to each null in vertical pattern passed through by aircraft flying at given altitude, for given frequency and ground antenna height

By **BENJAMIN LINDEMAN** Electronics Engineer, Rome Air Development Center, Rome, N. Y.

OFTEN it is necessary to determine the location of the nulls in the vertical antenna pattern of a ground-based antenna h feet above ground. This is usually correlated with an actual flight test using an aircraft flying at an altitude H feet above sea level. The usual procedure is to calculate the elevation angle θ where the nulls occur. For horizontal polarization,

$$\sin \theta = 492n/hf \qquad (1)$$

where f is in mc. For vertical polarization,

$$\sin \theta = 492(n + 0.5)/hf \qquad (2)$$

where θ is greater than 20 deg. These formulas are true regardless of the conductivity of the earth. Location is purely a function of ground antenna height.

The second step is to determine at what ranges the aircraft will encounter the nulls while flying at a fixed altitude of H feet. This calculation is complicated by the curvature of the earth. The relation between distance and elevation angle θ, taking the earth's curvature into consideration, is

$$H = \frac{15D^2}{17} + 6{,}000D \tan \theta \qquad (3)$$

where H is in feet and D is in nautical miles.

Using Eq. 1 or 2 and letting n take on values 1, 2, 3, 4, etc, the angles θ_1, θ_2, θ_3, etc for each null can be found. Substituting these angles in Eq. 3 together with altitude H of the aircraft will give distances D_1, D_2, D_3, etc which are the quantities sought.

Assume that frequency f = 1,000 mc and ground antenna height h = 1 foot. The nomograph in Fig. 1 then gives 30 deg as the angle of elevation of the first null (horizontal polarization). The other nulls are found by substituting h/n for h and letting n take values 2, 3, 4, etc for this polarization. For vertical polarization use $h/(n + 0.5)$.

To find the distances, enter the nomograph in Fig. 2 at 30 deg. Connect this point to the aircraft altitude H, in this case 30,000 feet. Since θ is less than 45 deg, use the D scale on the left and read 8.7 nautical miles. This corresponds to the first null for horizontal polarization. Figure 2 may also be used to calculate any of the quantities H, D, or θ if the other two are known.

The final pattern is the product of the free space pattern of the antenna and the ground interference pattern.

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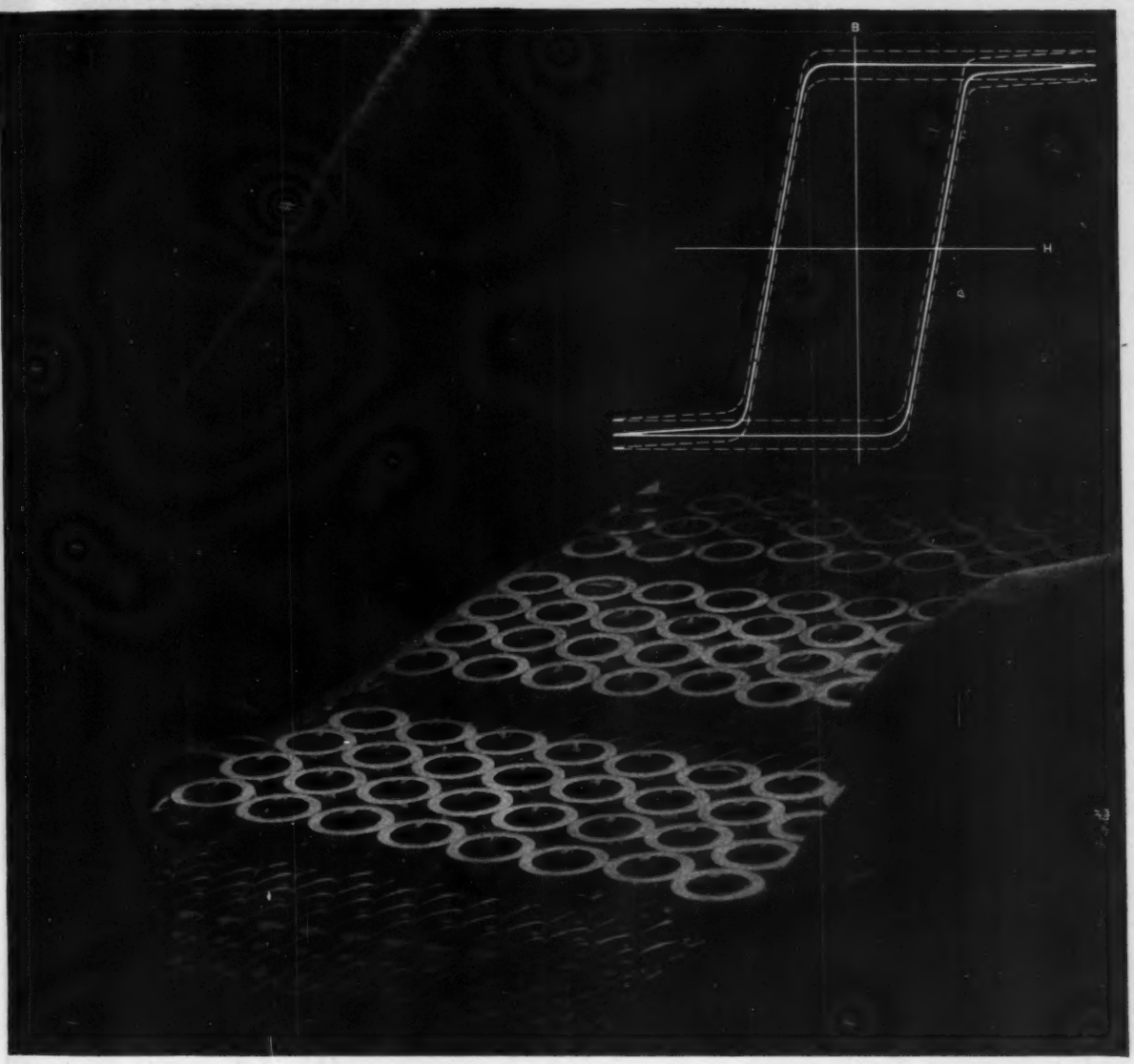

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*Paper No. 58-71, Winter General Meeting, AIEE, February, 1958. Flux Reset Test is one of two tests proposed for standardization.

CIRCLE 69 READERS SERVICE CARD

Two-Sided Matching Design

Curve plotted on Smith chart determines minimum values of shunt susceptance and the corresponding positions for two-sided matching of discontinuities in lossless transmission lines and waveguides

By **H. F. MATHIS,** Goodyear Aircraft Corp., Akron, Ohio

PROPERLY DESIGNED two-sided matching, as shown in Fig. 1A, may have better characteristics than matching with a single shunt susceptance.

A procedure is presented here for finding the values of B_1, B_2, d_1 and d_2 so that $(|B_1| + |B_2|)$ has the smallest possible value. For many applications, this is the optimum design. A B-curve plotted on a Smith impedance (R-X) chart in Fig. 2 is used. All impedances and admittances are normalized with respect to the characteristic impedance and admittance of the line.

First, the No. 2 terminals of the discontinuity are connected to a matched load and the impedance Z_1 at the No. 1 terminals is determined. For the example shown in Fig. 2, $Z_1 = 0.5 - j0.5$. The point Z_1 is plotted on the Smith chart. A circle is drawn with its center at the center C of the chart which passes through Z_1. This circle intersects the B-curve at the points A and D. The possible values of B are read at A and D. (For the example, $B_1' = 0.5$ and $B_1'' = -0.5$.) The corresponding values of d_1 are read as $d_1' = 0.193\lambda_g$ and $d_1'' = 0.482\lambda_g$, where λ_g is the transmission-line wavelength. The values of d_1 must be determined by going around the Smith impedance chart in a clockwise direction.

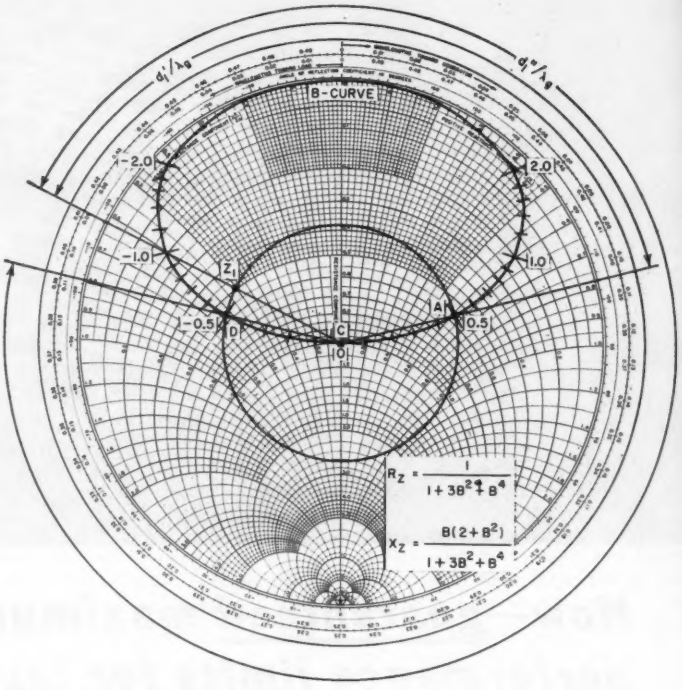

FIG. 2—Smith chart plot of B-curve

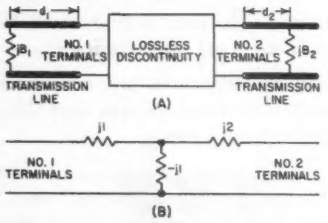

FIG. 1—Two-sided matching (A) and equivalent circuit (B) used in example. Parameters are impedances normalized with respect to characteristic impedance of the transmission line

The No. 1 terminals are now connected to a matched load and the impedance Z_2 at the No. 2 terminals is determined. The above procedure is applied to Z_2 to obtain the two values of B_2 and d_2. Since the discontinuity is lossless, $|B_1| = |B_2|$. For the example, $Z_2 = 1 + j1$, $B_2' = 0.5$, $B_2'' = -0.5$, $d_2' = 0.443\lambda_g$, and $d_2'' = 0.232\lambda_g$.

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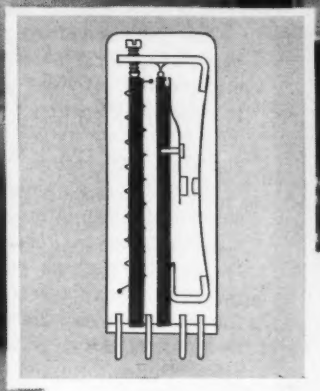

As heater causes the expansion member to stretch, lever pivots on its hinge, compressing the bow spring at a high rate in the direction of contact closure. Matching expansion member compensates for external changes in temperature between −65 and +100°C.

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System Reduces Tv Bandwidth

REDUCTION of tv bandwidth would permit more stations in the limited portion of the spectrum allotted to this type of transmission. Television, however, requires a rather broad band of frequencies to pass video pulses.

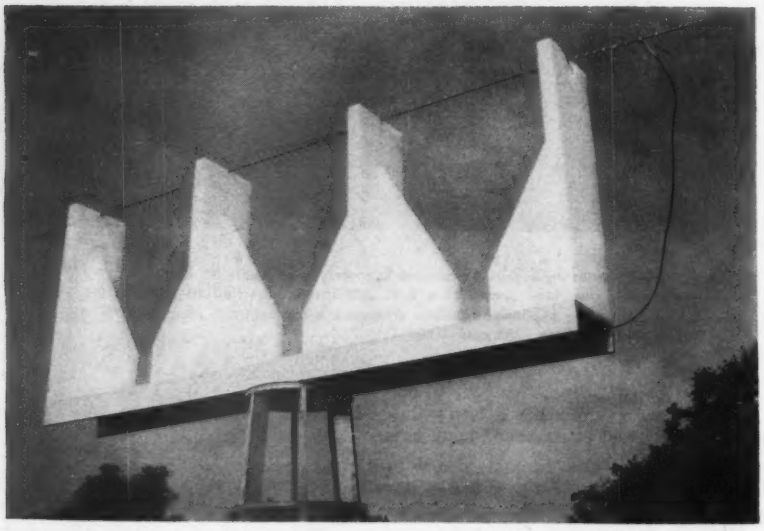
At the IRE show, one solution in the form of an experimental tv system was described by W. F. Schreiber and C. F. Knapp of Technicolor Corp. Basically, the system encodes the tv picture in digital form. The digits are decoded at the receiving end and used to reform the picture.

Correlation of successive picture elements along the scanning lines leads to groups or runs of cells having the same brightness. The system is regarded as being more efficient in transmitting information related to run length and brightness of the run, rather than brightness cell by cell.

From a video signal in which information is generated at rates varying from very high to very low, a coded signal is derived having a constant information rate. This is accomplished by creating a code group for each run which gives the brightness and the position of the run end. These code groups are stored long enough to average out the original information rate (one field in this system) and then transmitted at a uniform rate.

For decoding, the received code groups are stored as received for one frame. The code group corresponding to the first run-end position is read out and compared successively with locally generated code groups corresponding to successively later run-end positions until identity is indicated. Meantime the brightness output is held at the value originally read out at the same time as the first positional code group. In this way, the original video signal is recreated with correct timing.

Spiral Yagi Offers Higher Gain



TWIST ANTENNA supported on styrofoam for test was designed to provide more sensitive point-to-point radio and tv communication in the vhf-uhf range by Stanford Research Institute. A short segment of this antenna is similar to the common rod yagi tv antenna.

One distinct difference makes its extension beyond normal yagi length possible: the cross rods are displaced in a spiral around the axis.

Extending the length is desirable since the signal amplifying ability of an antenna normally increases proportionately to its length. In the case of the conventional yagi, however, there is a practical limit beyond which an increase in length yields very little increase in signal strength.

The spiral arrangement overcomes this limitation so that it is possible to take full advantage of a long axis. The pictured model is 10 feet long. Expectations are that it can be used advantageously up to many times this length and can be used in installations that would normally require expensive paraboloid antennas.

Output Is Function of Two Variables

SIMULATION of physical problems on an analog computer requires that empirical data be represented by functions of several variables. Such variables are handled in an analog computer by function generators that provide an output voltage varying in an arbitrary but controlled way according to the input voltages.

The National Bureau of Standards has constructed a function generator that produces an output as a function of two independent input variables. It is fully electronic, operates at much higher frequencies than electromechanical systems and can be built from commercially available equipment.

The instrument employs a number of single-variable function generators and provides a method for interpolating linearly between them. The x variable drives a number of function generators, while the y variable drives a number of voltage-controlled attenuators.

Each function generator, except for the first whose output corresponds to the value of the function for $y = 0$, is fed through an electronic attenuator. Each successive attenuator is adjusted to begin conducting when the previous one is almost fully on. All of the generators are fed in parallel from the x input.

The outputs of the attenuators are filtered and summed in the output amplifier. A portion of the output of each function generator is subtracted from the output through the use of an inverting amplifier. This compensates the residual output of the voltage-controlled attenuators when they are supposed to be off. A filter is used to make the freqency response of both amplifiers equal.

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SC-32-1	0-32	0-1	0.01	0.1	19"	3½"	13"
SC-32-1.5	0-32	0-1.5	0.01	0.1	19"	3½"	13"
2SC-32-1.5	0-32	0-1.5	0.01	0.1	19"	7"	13"
DUAL OUTPUT	0-32	0-1.5	0.01	0.1			
SC-32-2.5	0-32	0-2.5	0.01	0.1	19"	3½"	13"
SC-32-5	0-32	0-5	0.005	0.05	19"	5¼"	13"
SC-32-10	0-32	0-10	0.001	0.01	19"	8¾"	13"
SC-32-15	0-32	0-15	0.001	0.01	19"	10½"	13"
2SC-100-0.2	0-100	0-0.2	0.1	1.0	19"	5¼"	13"
DUAL OUTPUT	0-100	0-0.2	0.1	1.0			
SC-150-1	0-150	0-1	0.05	0.5	19"	5¼"	13"
SC-300-1	0-300	0-1	0.1	1.0	19"	8¾"	13"

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SC-32-2.5

tors receive their inputs from the y variable. A triangular wave is generated and compared to the y input. Whenever the triangular wave plus the y input exceed zero, the comparator turns on a gate to admit the output from one of the function generators.

There is a voltage-controlled attenuator for each function generator except for the case in which $y = O$. Whenever the triangular wave plus y is less than zero, the gate is turned off. The output of the gate, containing both x and y values, is filtered to remove the triangular wave. It is then summed with the outputs of the other gates to produce the desired $f(x, y)$.

While the system was designed to provide linear interpolation, it is possible to obtain nonlinear interpolation by changing the shape of the triangular wave.

Short and Breakdown Tester

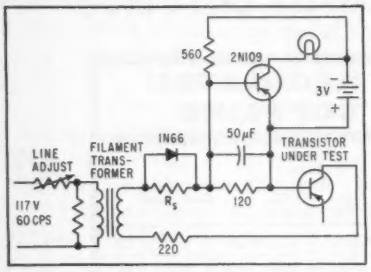


FIG. 1—A switch can be used for testing base-to-collector shorts in pnp transistors

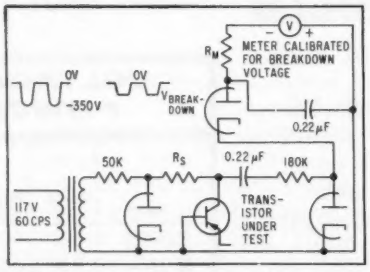


FIG. 2—Breakdown voltage of pnp transistors is shown on calibrated voltmeter

By MARVIN METH
Brooklyn, N. Y.

INTERELECTRODE shorts and collector breakdown voltage of transistors can be checked with the circuits to be described.

The circuit shown in Fig. 1 is a short-circuit test setup for indicating a base-to-collector short in a *pnp* junction transistor. The collector junction under test is driven in a class B manner by an a-c signal. This voltage should be 2.8, 5.6 or 11.2 volts rms, depending on whether the transistor is a low, medium or high-power unit. Low-power transistors are assumed to have a maximum collector current of 10 ma; medium, 100 ma and high, 2 amperes.

The 1N66 diode shunting R_s conducts during the half cycle that the junction is driven in reverse. Reverse current is limited principally by the back impedance of the junction.

A transistor in series with the junction senses an increase in reverse current above a threshold level. The transistor operates a pilot light that is always on. If reverse current in the junction under test exceeds the threshold value of 1.5 ma, the pilot light is extinguished, indicating a shorted junction.

A switch can be incorporated so that the emitter junction is checked for shorts in the same way. Another switch contact can be used to insert the test circuit between emitter and collector, with the base connected directly to the emitter. This arrangement can also be used to check transistor punch-through breakdown within the limitation of the peak value of the input voltage.

For measurement of collector-junction breakdown voltage, a half-sinusoidal wave of 350 volts peak value from a high-impedance source is applied to the collector junction. The circuit is shown in Fig. 2. The half cycle that is in a direction to forward drive the collector junction is clipped by the diode in the source network.

For back-bias voltages in excess of junction breakdown voltage, the transistor presents a low-impedance load to the source. The excess back-bias voltage appears across the source resistance consisting of R_s in series with 50,000 ohms. Thus, voltage swing across the junction is limited between the values of zero and breakdown.

An a-c voltmeter consisting of a full-wave rectifier and a d-c meter is connected across the collector junction. A d-c voltage directly proportional to the transistor breakdown voltage is developed across the rectifier output. The d-c meter is calibrated to read the actual breakdown voltage. The full-wave rectifier avoids the need for an *pnp-npn* polarity switch.

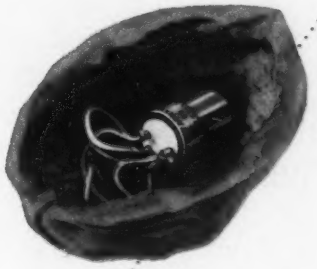
The meter has two scales, 500 and 100 volts. On the 500-volt scale, the maximum obtainable reading is 350 volts, which is limited by the peak a-c driving voltage.

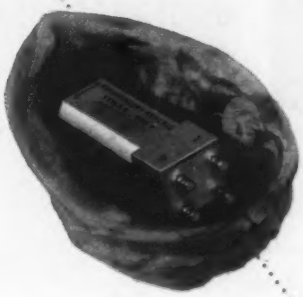
The driving-source resistance is selected to be low compared to the back resistance of the collector junction, and yet sufficiently large to limit the breakdown current of the collector junction to a safe value. The compromise requires two values of source resistance, 270,000 ohms for the low and medium power levels, 60,000 ohms for the high-power levels. Maximum possible power that the generator can deliver to a transistor, considered as a matched resistive

Autopilot Computer Uses 140 Transistors

Sophisticated autopilot for Hustler bomber is confronted with much more difficult job than in subsonic aircraft. (See ELECTRONICS, April 4, 1958, p 30) Brains of the system, this computer-amplifier being assembled by Bendix Aviation technician, controls surfaces in accordance with such variables as altitude, attitude, Mach number, gross weight, center of gravity and temperature

miniaturization in a nutshell





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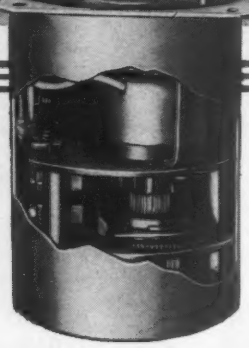

Eagle HYS Series Timer with Time Delay Feature

EAGLE SIGNAL engineers unique timer for Hughes airborne armament control system

A new electro-mechanical time delay device has been developed by the Eagle Signal Corporation for the Hughes Aircraft Company. Hughes uses the Eagle timer in an armament control system the company builds for the supersonic F-102A all-weather interceptor.

The Eagle timer is a hermetically sealed unit, actuated by a 28-volt d-c solenoid. The timer has been built to provide a delay in application of power to load circuit at the end of a timing interval. A rotary solenoid winds a spring on the escapement mechanism, and timing begins when the solenoid is energized. The Eagle timer operates under rigorous environmental conditions, and is built to withstand extra heavy duty applications.

Development of this special Eagle timer is just one example of the electronic and aeronautical engineering "know-how" to be found at Eagle Signal. Consult Eagle Signal on your timing and counting problems *early in your planning.* And write for Bulletin 820 for more information on the escapement timer. Eagle Signal Corporation, Dept. E-458, Moline, Illinois.

load, is 27 mw for low and medium and 125 mw for high-power units.

Collector-to-emitter punch-through voltage can be measured by connecting the emitter of the transistor under test to the transistor base.

Oscillator Reduces Recorder Stiction

By **RONALD L. IVES**
Palo Alto, Calif.

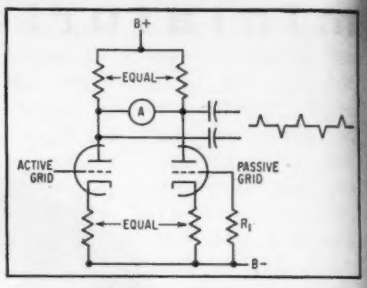

FIG. 1—Difference amplifier for radiation monitor uses passive grid to cancel effects of contact potential at active grid

CONTINUOUS chart recorders of many types require a certain small lateral oscillation of the pen at all times to offset the effects of paper drag, ink viscosity and bearing friction in the movement. In most instances, a symmetrical oscillation of about 0.5 times the line width, at a frequency of roughly 5 cps, is optimum.

Keep-alive pulses for this function are customarily supplied by a relay oscillator in battery-operated field equipment and by a buffered multivibrator in station-type equipment.

Keep-alive pulses are usually applied from plate to plate of a difference amplifier such as that shown in Fig. 1. D-c isolation is provided by fairly large isolating capacitors. This arrangement works well in a large number of installations but requires about 70 watts for generation and insertion of the pulses. As the actual pulse power required is in the realm of milliwatts, efficiency is very low and heat production very high.

This type difference amplifier is often used in radiation monitors. Insofar as signal is concerned, the passive grid does nothing. It is

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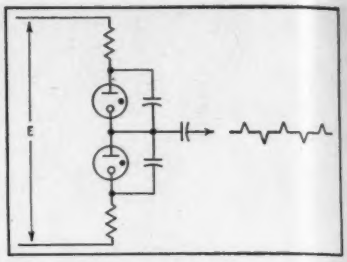


FIG. 2—Back-to-Back neon oscillator generates low-amplitude positive and negative pulses

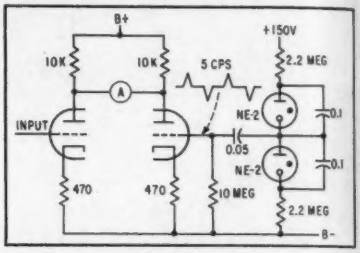


FIG. 3—Low-amplitude pulses injected at inactive grid of difference amplifier get more work out of triode half

useful, with its series resistor R_1, only as a balancing element to offset contact potential developed in the active grid.

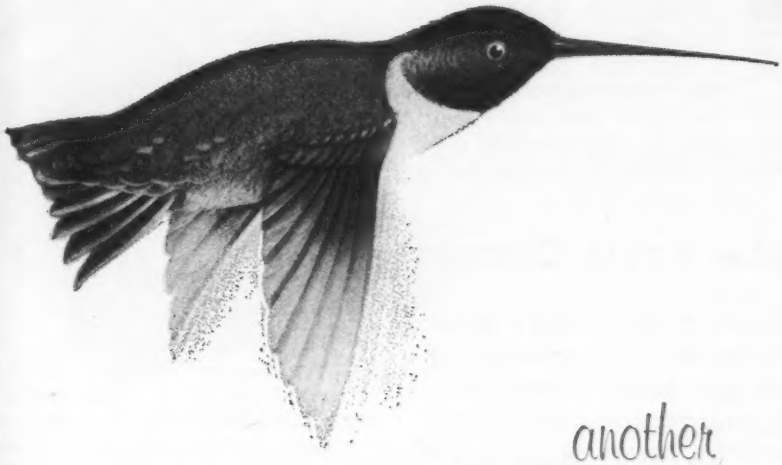
Any signal injected at the passive grid is amplified at the plate and is indicated on the recording instrument. Therefore, it appears that a very small signal of requisite waveform injected at the passive grid, would supply the necessary keep-alive pulses at a great saving in power and equipment.

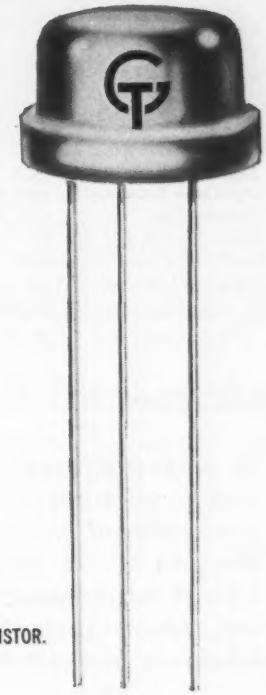
Source of these signals is the symmetrical neon oscillator shown in Fig. 2. It will be recognized as two conventional neon oscillators connected back-to-back. Satisfactory operation with NE-2 lamps is secured at any supply voltage of 150 or more and at any frequency up to about 500 cps with stock lamps and components. Higher frequency operation (not needed in this application) is possible only by careful matching of components.

Circuit of a difference amplifier, supplied with keep-alive pulses injected at the passive grid, is shown in Fig. 3, with working constants. Higher voltage operation of the oscillator is practical if the series resistors are increased.

Voltage regulation of the oscillator is not necessary, since a change in supply voltage will not vary the pulse amplitude.

ready to go in either direction





another

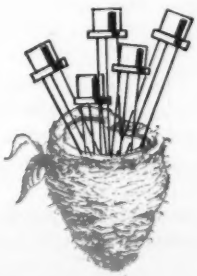
NEW PRODUCT FROM GENERAL TRANSISTOR.

NEW PNP AND NPN BILATERAL TRANSISTORS HAVE EMITTER AND COLLECTOR INTERCHANGEABILITY

General Transistor has developed another new transistor series —the Bilateral PNP 2N592, 2N593 and NPN 2N594, 2N595, 2N596. These germanium alloyed junction transistors have been designed to allow current to flow in either direction— valuable in medium speed switching applications as in computers, communications equipment, multiplexing devices, and for bi-directional switching and phase detection systems.

The characteristics of these transistors are guaranteed in both directions. Their symmetrical design allows extremely low saturation resistances and switching properties. Ordinary uni-directional types lack this advantage. The NPN types have an alpha cutoff frequency range of 1.5 to 10.0 megacycles.

For complete technical specifications write for illustrated brochure G-170.



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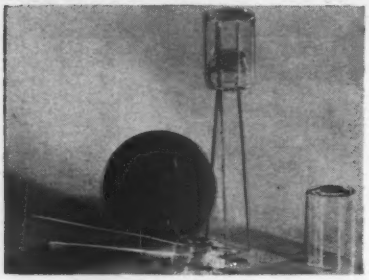
Glass Envelope For Transistors



Glass base and lead wires (left) and cover (right) are hermetically sealed to make transistor case

THE FIRST all-glass transistor enclosure manufactured in this country was introduced by Corning Glass Works at the IRE Convention.

Production of the two-piece transistor case was made possible by the development of a new, close-control electric sealing process. The base and cover are hermetically sealed at 1000 C while temperature near the semiconductor, less than ¼-inch away, is kept below 150 C. Sealing time is approximately 10 seconds.

According to a Corning representative the glass enclosure is well suited for mass production. Economy of the base and cover plus a decrease in assembly cost will result in a lower priced transistor.

The glass to glass hermetic seal has no products of combustion and can be done in a controlled atmosphere. With the transistor in a vertical position, the envelope is perfectly smooth and has no lip or edge for moisture to collect on.

Both base and cover of the 200 mil lead circle-enclosure are made of strong, thin-walled precision glass tubing of high purity.

Current production of the new transistor case is limited to the 200 mil lead circle type for low power units. Other sizes will be available in the near future.

Fundamental Tube Fault Corrected

A mass-produced frame grid structure practically eliminates many of the problems of conventional electron tube grids. Tubes using the grid have higher transductance, less vibration of tube characteristics, lower "knee" voltage, lower microphonics, and greater overall efficiency and reliability.

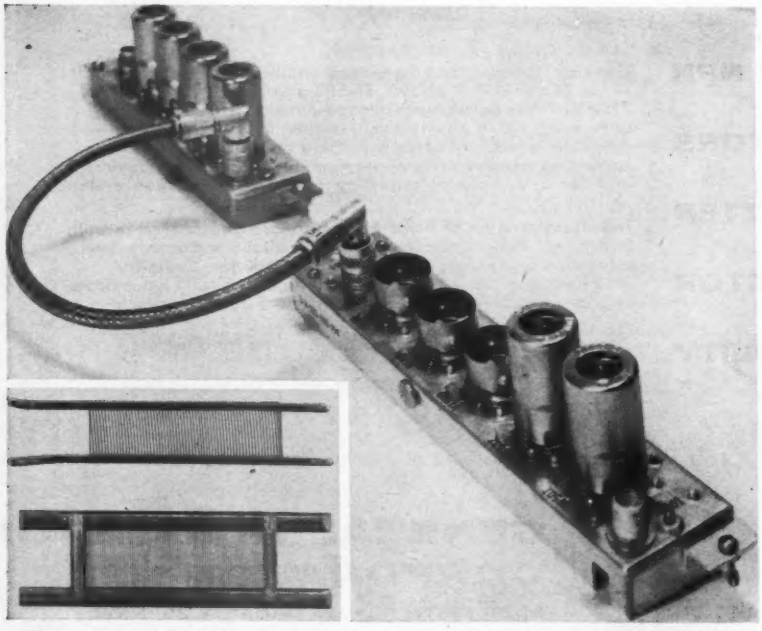


FIG. 1—Improved tube characteristics with frame grids reduce the number of tubes and components necessary to perform a given operation. (Insert) Conventional grid top and Amperex frame grid below

THE GRID in an electron tube can be very effectively compared with the steering wheel on a car. A small amount of force applied to the steering wheel will direct 3000 pounds of automobile. Automobile manufacturers exercise great care to build accurate reliable steering mechanisms. And as cars became bigger power steering was introduced to maintain the accuracy and dependability.

Tube manufacturers have recently made a complete design change in the control mechanism of certain tube types. Ideally only the electrical characteristics of a grid should effect tube operation.

Grid Dimensions

In practice you can simulate this ideal condition if you know the exact physical configuration of the grid and if you can maintain this same configuration in every tube constructed. In this way physical characteristics of the grid will have exactly the same influence on the electrical characteristics of each tube produced. With a grid which has the same physical influence on all tubes of a particular type, tube electrical characteristics—to the user—are independent of grid construction.

Once a technique is developed to accurately control grids dimen-

Sierra 185A-15FN Wattmeter

Sierra 164 Power Monitor

Swift, simple, accurate

WATTMETERS

Average-reading termination instruments — 15 to 500 watts; 20 MC to 1,000 MC

POWER MONITORS

Bi-directional; measure incident or reflected power; 10 MC to 1,000 MC

Sierra Termination Wattmeters and Bi-directional Power Monitors are specifically engineered for convenient, accurate measurement of rf power, incident and reflected power; matching antennas and loads; and terminating rf coaxial systems.

Three Model 185A series Average-Reading Termination Wattmeters cover three power ranges as indicated under "Specifications". These rugged, dependable instruments require no auxiliary power source, and are ideal dummy loads for testing and adjusting CW, AM and FM transmitters and oscillators. They are conservatively rated, with negligible rf leakage.

Sierra 164 series Bi-directional Power Monitors are direct-reading, versatile instruments covering 10 MC to 1,000 MC with as few as two plug-in elements. A wide selection of plug-ins permits measurement of incident or reflected powers over all ranges from 1 to 1,000 watts. Reversal of power flow is achieved simply by turning a control knob on the plug-in element in use. High directivity and low VSWR insure maximum accuracy with minimum disturbance to the transmission line under test.

SPECIFICATIONS

SIERRA 185A SERIES WATTMETERS

Model	Frequency	Power Range, Watts	Max. Power Dissipation
185A-15FN	20 MC - 1,000 MC	0 - 5/15	15 watts
185A-100FN	20 MC - 1,000 MC	0 - 30/10	100 watts
185A-500FN	20 MC - 1,000 MC	0 - 150/500	500 watts

Accuracy ±5% full scale. Max. VSWR 1.2. Type N female connectors standard.

SIERRA 164 SERIES POWER MONITORS

(Monitors require plug-in element for operation. See 180/181/270 Series data below)

Insertion VSWR:	Less than 1.08 except on 1 watt ranges; less than 1.15 on 1 watt (with Type N connector)
Accuracy:	±5% full scale, all ranges
Impedance:	50 ohm coaxial line
Weight:	7½ lbs., with 1 plug-in
Connectors:	N, UHF or C*. (*Special order)

SIERRA POWER MONITOR PLUG-INS

Model	Power Ranges	Frequency Range
180-52	1, 5, 10, 50 watts	25 MC to 52 MC
180-148	1, 5, 10, 50 watts	50 MC to 148 MC
180-470	1, 5, 10, 50 watts	144 MC to 470 MC
180-1000	1, 5, 10, 50 watts	460 MC to 1,000 MC
181-250	10, 50, 100, 500 watts	25 MC to 250 MC
181-1000	10, 50, 100, 500 watts	200 MC to 1,000 MC
270-75	50, 100, 500, 1,000 watts	10 MC to 75 MC

Data subject to change without notice

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sions, electrical characteristics of the tube can be optimized by selecting the proper spacing between grid wires and between grid and cathode. In the past grids have been made by winding wire around two rods and then placing the rods through holes in mica spacers. The drawbacks of this technique for premium-quality tubes are tremendous. Distance between the rods is determined by the accuracy of the holes in the mica washers.

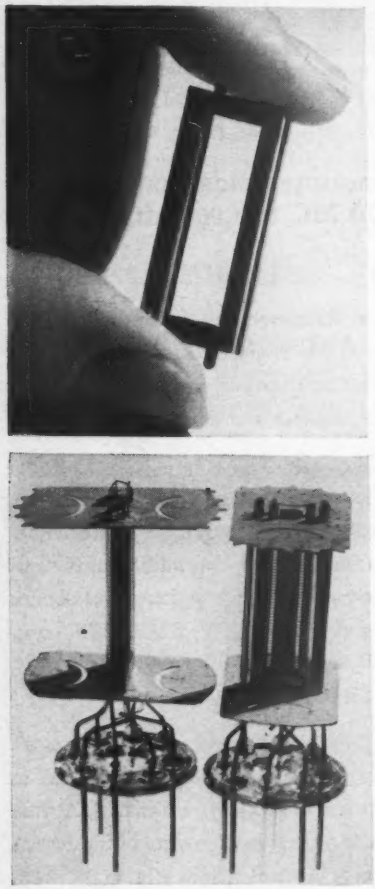
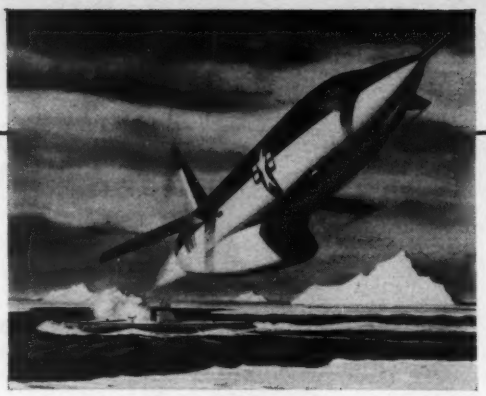


FIG. 2—"Framelok" the Sylvania frame grid has individual wires stretched across the frame (top). Precision slots in the mica accurately position the grid (bottom)

If the rods are not the proper distance apart, the grid wires will sag and disrupt grid wire spacing. If one of the rods is pushed up or down when mounting the grid in the tube, the grid wires will slant from rod to rod instead of being perpendicular to each rod. This is particularly troublesome in multigrid tubes since proper operation



Key Openings for Electronics Engineers

Electronics activities are broad and fast-growing at Chance Vought. Projects involve advanced guidance and control and fire control systems for missiles and high-performance manned aircraft. They begin with investigations and theory and progress through systemization and packaging to detailed hardware design. Key responsibilities await additional men who are qualified in these areas. Advanced degrees are preferred.

Stability and Control Engineer. E.E., M.E., or A.E. with emphasis on flight stability and control problems or dynamics. (Special consideration given graduate study or extensive experience in transients or closed loop stability analysis.) To assist in design of autopilot and control systems for high-performance missiles and aircraft.

Antenna Design Engineer. E.E. or Physics Degree with demonstrated aptitude for antenna design. To join active projects involving design of flush-mounted, recessed and external antennas at all frequencies for very high-performance aircraft and missiles.

Fire Control and Microwave Systems Engineer. Requires E.E. or Physics Degree; at least 2 years experience in radar, data link, or fire control systems; and strong ability in this work.

Test Equipment Engineer. Requires E.E. or Physics Degree and at least 2 years experience in this or related field. (Desirable: broad background in electronics design with emphasis on digital computers or microwave systems.) To join in the design of complete checkout systems for missiles and associated subsystems.

Guidance Design Engineer. E. E. or Physics Degree, plus 2 or more years experience. To design various active and self-contained missile guidance systems, and to design and develop radar beacons.

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Electronic Packaging Engineer. M.E., E.E., or equivalent packaging design experience. To help design ground, airborne and shipboard electronic equipment for use in severe environments. Involves consideration of heat transfer, shock, vibration and other factors.

To arrange for a personal interview, or for more information on these or other current openings, return coupon to:

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I am a_____ Engineer,
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Vought Vocabulary

in′ge·nu′i·ty: *designing a 12-ton missile to fit inside an atomic sub*

Chance Vought's *Regulus II* missile is twice as long as a city bus. It is crammed with delicate instruments, armed with a nuclear warhead. Yet Vought engineers designed *Regulus II* to serve safely, efficiently aboard the Navy's newest nuclear-driven submarines.

They shock-proofed the missile against underwater blasts. They conditioned it for polar ice, or equatorial heat. They made it – like Vought's smaller Fleet veteran, *Regulus I* – a dependable weapon, accurate from conventional or nuclear subs, from surface ships or highly maneuverable, mobile shore launchers.

Aboard its special, globe-girdling sub, *Regulus II* will move *invisibly* any distance to its launching point. There it can begin a supersonic, long-range strike in minutes. Or it may lurk unseen for months as a patient and ready deterrent.

A chilling prospect for would-be aggressors, this example of Vought ingenuity.

Scientists and engineers: pioneer with Vought in new missile, manned aircraft, and electronics programs. For details on select openings write to: C. A. Besio, Supervisor, Engineering Personnel, Dept. R-3.

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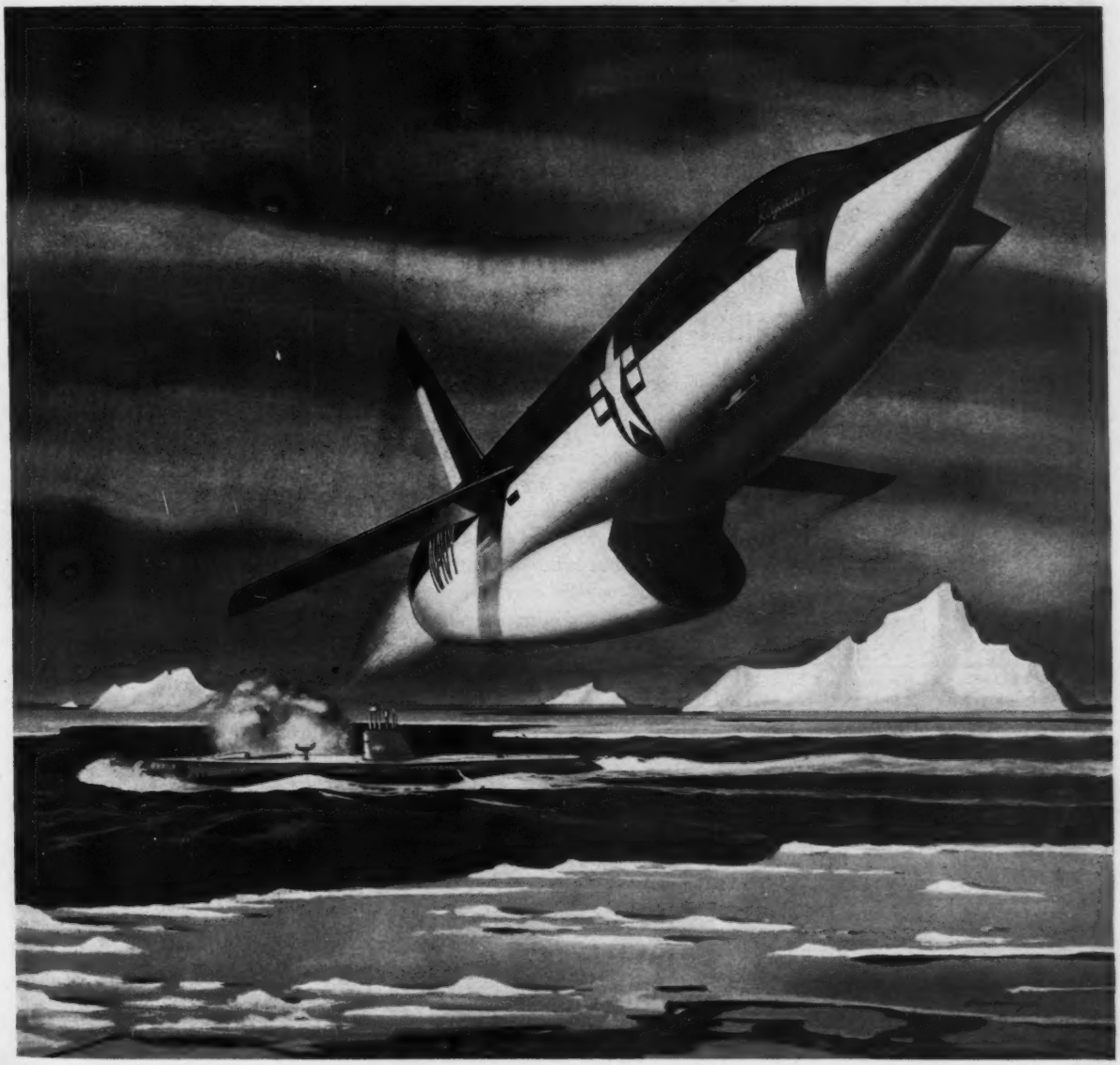
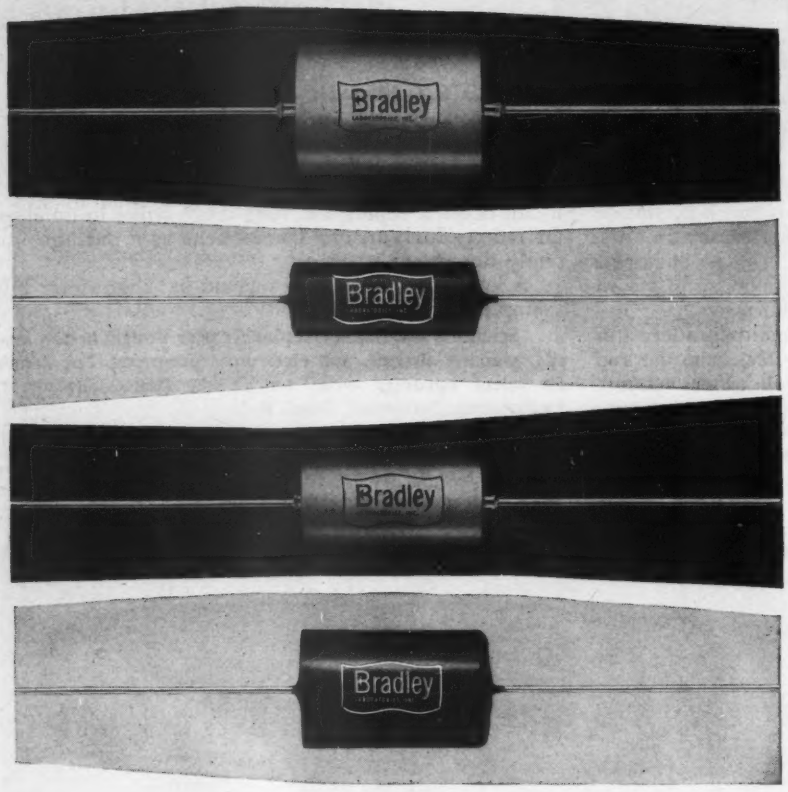


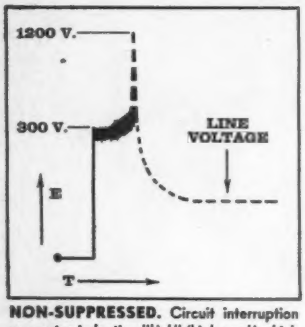
SP7 SERIES moisture-sealed phenolic housing

SP3 SERIES hermetically sealed metal housing

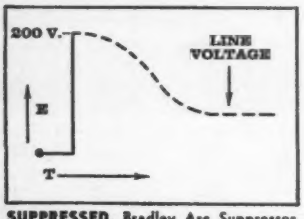


Bradley Selenium Rectifiers for Arc Suppression

PROTECT CONTACTS AGAINST ARC-INDUCED EROSION



NON-SUPPRESSED. Circuit interruption generates inductive "kick" (high peak) which creates arc across contacts.



SUPPRESSED. Bradley Arc Suppressor dissipates inductive load, prevents arcing.

When interrupted, every inductive circuit "kicks" back. Coil de-energization generates a high inductive potential which explodes in a metallic arc across contacts and sends transient surges through the circuit. Contacts erode — then lock or stick. Components operating at maximum rating break down under the voltage overload.

These conditions are eliminated by Bradley Selenium Rectifiers for Arc Suppression. Small in size, low in cost, and easily connected across any inductive element, these rectifiers block the inductive kick and prevent arcing. They perform this function without noticeably slowing circuit operation. For more information, please write for Technical Bulletin, "Bradley Selenium Rectifiers for Arc Suppression."

Bradley LABORATORIES, INC.

BRADLEY LABORATORIES, INC., 168E Columbus Avenue, New Haven 11, Connecticut

occurs only when grid planes are parallel and grid wires parallel and directly in line with each other.

Mass Production

Two companies, Amperex Electronic Corp., 230 Duffy Ave., Hicksville, N. Y. and Sylvania Electric Products, 1740 Broadway N. Y. 19, N. Y. are mass producing tubes with frame grids. Sylvania has started production on a 6FH6 horizontal deflection tube for television receivers. The grid, shown in Fig. 2, has individual wires stretched across a frame structure and clamped. The frame is precision notched and can be easily assembled in a tube to very close tolerances.

Less Power

Because of the accurate grid construction less screen grid power is required for a given plate power. Fewer electrons traveling from the cathode to plate collide with the grid wires. Since the frame grid has a greater mass it is capable of dissipating more heat. The inherently lower grid emission and larger heat dissipating area make it possible to achieve higher peak plate currents before dissipation becomes a limiting factor. The Sylvania 6FH6 will also supply increased power output since its plate voltage can swing to a very low value without encountering unduly high screen grid currents. Higher screen voltages can be maintained at lower dissipation levels resulting in higher output peak current and power. These conditions are ideal for TV horizontal deflection tubes.

Grid to Cathode Spacing

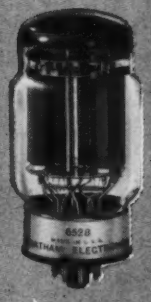
The frame grid mass produced by Amperex, Fig. 1, uses the rod structure found in conventional grids, but eliminates conventional grid difficulties by cross-braces between the rods. Extremely fine wire is wound around the frame, since the wire has absolutely no supporting function to perform, as it would in a conventional grid. Grid to cathode spacing, determined by the carefully controlled diameter of the rods, can be made very small with the rigid structure. Four tubes the 5847, 6688, 6922, and 6939 are now being mass pro-

Specialists in special purpose tubes

THYRATRONS—An extensive line of thyratrons for use as grid control rectifiers, relays and noise generators. Inverse voltage ranges from 100 to 5,000 volts. Sizes from subminiatures to ST 16 bulbs. Filamentary as well as hot and cold cathode types are available.

RECTIFIERS—Both vacuum and gas filled tubes with peak inverse voltage ratings from 200 to 15,000 volts. Included are tubes with special features such as fast warm-up, cold cathodes, clipper service ratings and rugged construction.

VOLTAGE REGULATOR AND REFERENCE TUBES—Gas filled tubes designed to specific voltages for regulating small currents. Also used to make available stable reference voltages for high current supplies. Sizes from subminiatures to bantams, including many reliable, ruggedized types.



TWIN POWER TRIODES—The most complete line of high current twin power triodes developed especially for regulated power supply usage. Current and power ranges up to 800 milliamperes and 60 watts respectively. Included are rugged types in both low and medium mu construction.

TELEPHONE TYPES—A highly specialized line of vacuum and gas filled types in both the 300 and 400 series.

HYDROGEN THYRATRONS—Used primarily as switching tubes in line type radar modulators, these tubes permit accurate control of high energy pulses. Sizes from miniatures to the VC 1257. Peak pulse power ranges from 10 kilowatts to 33 megawatts.

Chatham research and development has produced many new tube types that have become industry standards. If you have a special purpose tube problem, Chatham experience can help you find the solution.

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Lapp

duced with frame grids by Amperex.

Because grid to cathode spacing can be reduced to 0.05 millimeters with frame grids, a thirty percent increase in gain-bandwidth product is obtained. An extra measure of rigidity is achieved since the grid wire is wrapped around the frame under tension. The result is a strong, rigid structure not sensitive to microphonics.

Less Tubes and Component

High efficiency, resulting from frame grid construction, reduces the number of tubes and components needed to construct many circuits. The reduction in parts in turn effects an increase in reliability simply because there are less parts which can become defective.

Effective Power With Transistors

HYPER-PURE SILICON, obtained with the Siemens refining process developed by Siemens Schuckertwerke and Siemens Halske in Germany, has pushed power-handling capabilities of silicon transistors up to a useable 1 kw. It is called effective power because of the high emitter-to-collector voltage rating.

Without ambient cooling or heat sink devices, the transistors can be operated at 2-5 amps with emitter-to-collector voltages ranging from 50 to over 300 volts. The low saturation resistance of the transistor results in very little internal heat dissipation. Current ratings are specified for operation at a current gain of 10 amps.

Reverse leakage current of the silicon transistors produced at Westinghouse Semiconductor Division, Youngwood, Pennsylvania is about 2 to 3 ma. The low saturation resistance makes it an efficient high-power switching device. As a d-c switch handling 1 kw (200 volts at 5 amperes), internal dissipation is about 5 watts with a resulting efficiency of over 99 percent.

In order to take advantage of the hyper-pure silicon obtained with the Siemens process, new fusion and diffusion methods were developed, together with improved alloy

New – SEND TEST SIGNALS DURING PROGRAMMING

American Broadcasting Co.
Mr. R. Morris (left) & Mr. J. Serafin

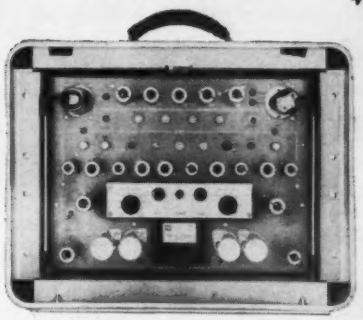
TELECHROME MFG. CORP.

VERTICAL BLANKING INTERVAL TEST SIGNAL KEYER

The Telechrome Model 1008-A Vertical Blanking Interval Keyer is a self-contained portable unit that makes possible transmission of television test and control signals between frames of a TV picture. Any test signal (multiburst, stairstep, color bar, etc.) may be added to the composite program signals. The keyer will operate anywhere in the TV system and operates from composite video, sync, or H & V drive. The test signals are always present for checking transmission conditions without impairing picture quality. The home viewer is not aware of their presence.

These continuous reference signals may be used in connection with various Telechrome devices for automatic correction of video level, frequency response, envelope delay, differential gain and differential phase.

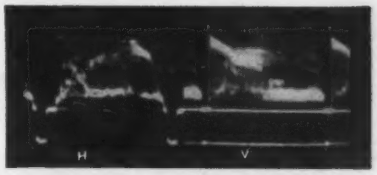
MODEL 1008-A



VERTICAL BLANKING INTERVAL TEST SIGNAL KEYER

Portable or standard rack mounting. Self-contained power supply.

Test signal is thin line between frames. All test signals can be transmitted during vertical blanking portion of program.



Video picture with multiburst test signal inserted, as seen on ordinary wave monitor.

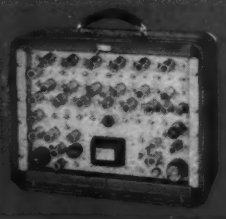
IMPORTANT:

Checking after programming is costly and at best highly inefficient since conditions constantly vary. The Telechrome Vertical Interval Keyer minimizes post-program checking and overtime expenses. It provides instant indication of deteriorating video facilities so that corrective measures can be undertaken immediately—manually or automatically during programming.

Now in use by CBS, NBC,
ABC, BBC ITA (Brit.)

1003-C VIDEO TRANSMISSION TEST SIGNAL GENERATOR

Completely self-contained, portable. Produces multi-frequency burst, stairstep, modulated stairstep, white window, composite synch. Variable duty cycle. Regulated power supply. 12¼" standard rack mounting or in carrying case. Integrates with above model 1008-A Test Signal Keyer.



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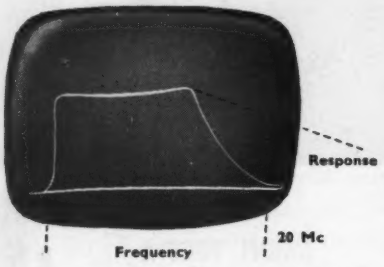
DIRECT DISPLAY OF RESPONSE UP TO 20 Mc

The Marconi 20-Mc Sweep Generator can be used in conjunction with any oscilloscope for direct display of video response characteristics up to 20 Mc. The instrument is designed for precise measurement. Frequency is indicated by crystal-controlled marker pips; and a special circuit provides for differential amplitude measurements, enabling relative response to be determined with a discrimination better than 0.01 dB.



MARCONI 20-Mc SWEEP GENERATOR TYPE 1099

Abridged Specification

Frequency Swept Output: Frequency Range: Lower limit 100 kc, Upper limit 20 Mc. Output level: Continuously variable from 0.3 to 3 volts. Output Impedance: 75Ω. *Time Base:* Repetition Rate: 50 to 60 cps. Output for c.r.o. X deflection: 250 volts. *Frequency Markers:* At 1 Mc intervals; every fifth pip distinctive and crystal controlled. Tubes: 6AK5, 6BH6, 5763, 6BJ6, 6CD6G, 6BE6, 12AT7, 12AU7, 6C4, 5V4G, OA2, 5651.

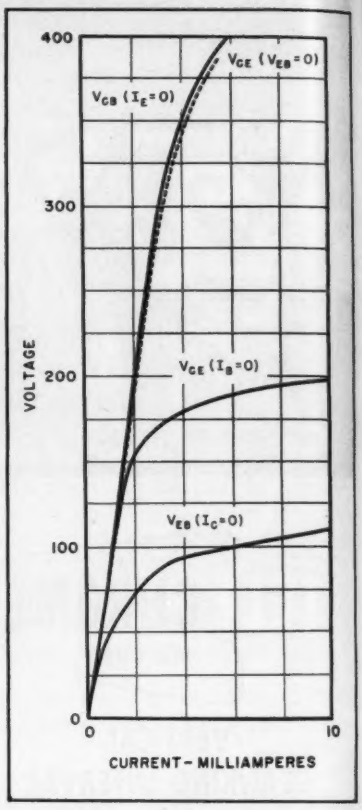
Send for leaflet B124/B

MARCONI INSTRUMENTS

111 CEDAR LANE
ENGLEWOOD
NEW JERSEY
Tel: LOwell 7-0607

CANADA: CANADIAN MARCONI CO • 6035 COTE DE LIESSE • MONTREAL 9
MARCONI INSTRUMENTS LTD • ST. ALBANS • HERTS • ENGLAND

TC124



Voltages characteristics of 2-5 ampere power transistor: Collector-base, collector-emitter and emitter-base voltage in the 300 v rating are 3 to 4 times higher than previous silicon power transistors

systems, etching procedures and encapsulation techniques. The col-

10-20 A Power Transistor

Principles and techniques used in developing the 2-5 ampere transistor have been extended to produce a device capable of handling up to 3 kw. Voltage ratings (collector to emitter) on present 10-20 ampere units range from 50 to 150 volts. Westinghouse feels that development work should increase this range to 300 in a short time.

As with the 2-5 ampere devices, current ratings are specified at a current gain of 10 A.

High current and voltage ratings again represent high-power handling capacities—only if the internal dissipation is low. Saturation resistance for the 10 to 20A transistor varies from 0.1 to 0.05 ohm. Used as a d-c switch, it will handle 3 kw of power with a internal loss of less than 20 watts.

SERVICE SERVICE SERVICE

Moloney Electric Company has the industry's largest and most modern facility for producing wound cut cores. To our customers, this means top quality in production or prototype quantities. Most orders are shipped from a "perpetual inventory controlled" stock of 40,000 cores

Just phone your core requisitions to your Moloney representative, and then let "Moloney's Three-Point Service Plan" take over.

MESO-5

1

STOCK SHEET

Each Monday our customers receive a stock sheet listing actual stock figures on more than 140 popular production-run HyperCores. If you, too, desire this service, write the Moloney factory.

2

MASTER HYPERCORE BOOK

1500 standard and special cores, with dimensions, prices, and quantity in stock kept current daily. For immediate, accurate answers concerning cores, contact your Moloney representative.

3

SHIPPING NOTICE

The same day your HyperCore shipment is made, we air mail a card giving complete order and shipping information. This card helps you with production scheduling and saves on expediting costs. Avail yourself of this service —order Moloney HyperCores.

MOLONEY ELECTRIC COMPANY

Plate and Filament Transformers • Chokes • Unit Rectifiers • Modulation Transformers and Reactors • Pulse Transformers and Charging Chokes • HyperCores for Magnetic Components Developmental Magnetic Components • Power and Distribution Transformers

SALES OFFICES IN ALL PRINCIPAL CITIES
FACTORIES AT ST. LOUIS 20, MISSOURI AND TORONTO, ONT., CANADA

Merry-go-round Feeds Bobbins to Coil Winder

WORKING PROTOTYPE of a semi-automatic coil winding machine was one of several recently developed refinements in production equipment displayed at the IRE Show.

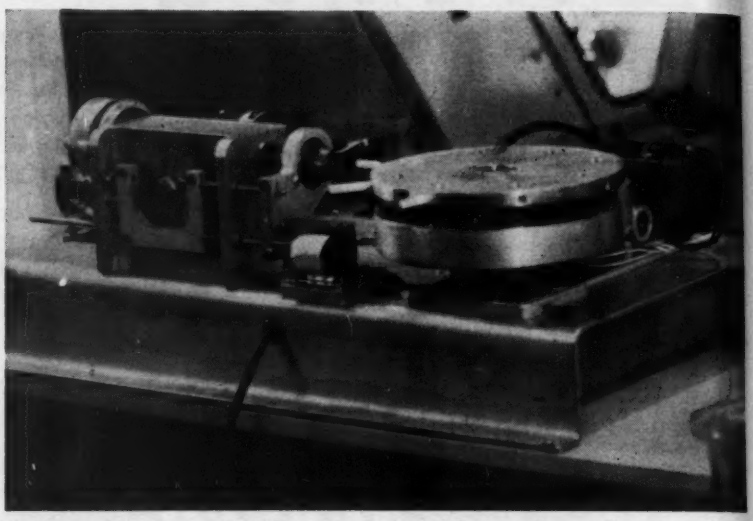
The machine shown by Coil Winding Equipment Co., Oyster Bay, N. Y., differs from conventional models by using a merry-go-round to hold bobbins.

The operator inserts bobbins in holes in the wheel. Each time a foot pedal is pressed, a bobbin is brought into winding position. Wire is fed into a guide which rotates around the bobbin. The bobbin remains stationary.

Bobbins are wound in this manner until the spool of wire is used up, without further threading of the wire through guides. For fully automatic operation, bobbins could be mechanically inserted in holes in the merry-go-round.

Associated American Trading Division, New York, N. Y., showed an electronic wire guide for coil winding machines. The guide compensates for variations in wire diameter to keep one turn of wire snug against the preceding turn.

The control unit regulates current fed to the traverse motor. Ordinarily, the traverse would move at a constant speed. The new control has a guide mounted on a sliding pin between two contacts. When the wire is not being tightly wound, contact slows the traverse.



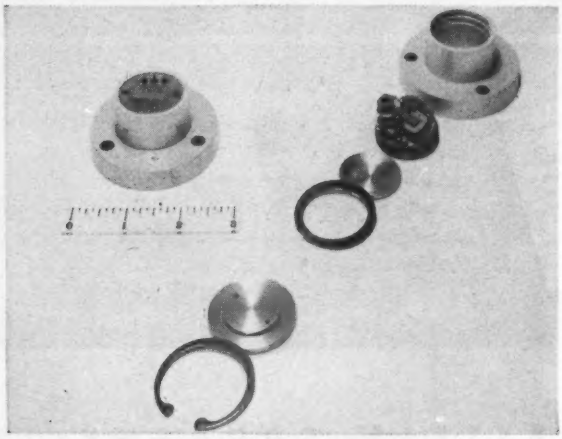
Working model of new coil winder uses wheel at right to position continuous supply of bobbins under rotating wire guide

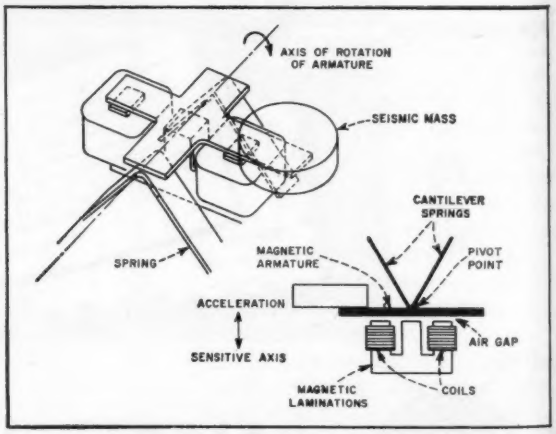
High-speed wire cutters and strippers were displayed by Artos Engineering Co., Milwaukee, Wis., and Jennings Machine Corp., Philadelphia, Pa.

The Artos machine pulls wire into position with two shuttle-like heads. It can handle two spools of wire at once for speeds up to 8,000 pieces an hour. Wires can be dropped lengthwise on conveyors for automatic attachment of terminals. Wire length is set on a scale.

Jennings' machine achieves

DESIGN TRENDS: Rotating Armature Accelerometer





Rotating flat armature, hung on cantilever spring, is heart of this rugged accelerometer produced by Wianko Engineering Co., Pasadena, Calif., for aircraft and missile control and telemetering. Seismic mass (Fansteel 77) is fixed to armature suspended over E-core. Acceleration of mass rotates armature, varying air gap. Change in coil inductance gives electrical output proportional to acceleration. Low stress in Nispan spring, absence of linkage and pivots results in hysteresis of 0.1 percent or less and acceleration crosstalk effect as small as 0.0025 G/G. Air bubble, metallic bellows or plastic diaphragm protect case from temperature-induced changes in damping fluid volume, or a heater maintains fluid temperature. Range of models is ½ G to 1,000 G; carrier frequencies, 400 cps to 10 kc.

NOW EVEN MORE TANTALUM CAPACITORS

from FANSTEEL

One of the dominant reasons for building the Oklahoma plant was the great demand which grew out of Fansteel's development of the tantalum capacitor. Fansteel produces a complete line of tantalum capacitors, and in addition, supplies tantalum materials and components to other leading capacitor manufacturers.

Fansteel's new facilities can now produce 11 times more tantalum capacitors than were produced in the United States during 1957.

With the big new plant in Muskogee, Oklahoma and expanded facilities at North Chicago in full operation, all Fansteel tantalum capacitors can now be shipped *from stock*.

As the world's first major producer of tantalum capacitors, Fansteel recognized the rapidly increasing need for more tantalum and initiated a $1,000,000 expansion program at North Chicago in 1955. In less than six months, even more production was needed to meet the constantly growing demand. So the $6,500,000 Muskogee tantalum-columbium plant was planned, privately financed, and built with the most modern automated and cost saving equipment.

All of this adds up to more Fansteel tantalum capacitors ... delivered on time ... in quantities to meet any of your production requirements.

Ask for latest bulletins on these Fansteel capacitors:

Bulletin 6.100—Type "PP" . . . General Purpose
Bulletin 6.113—Type "VP" . . . Vibration Resistant
Bulletin 6.111—Type "HP" . . . High Temperature
Bulletin 6.112—New Type "STA" . . . Solid Tantalum*

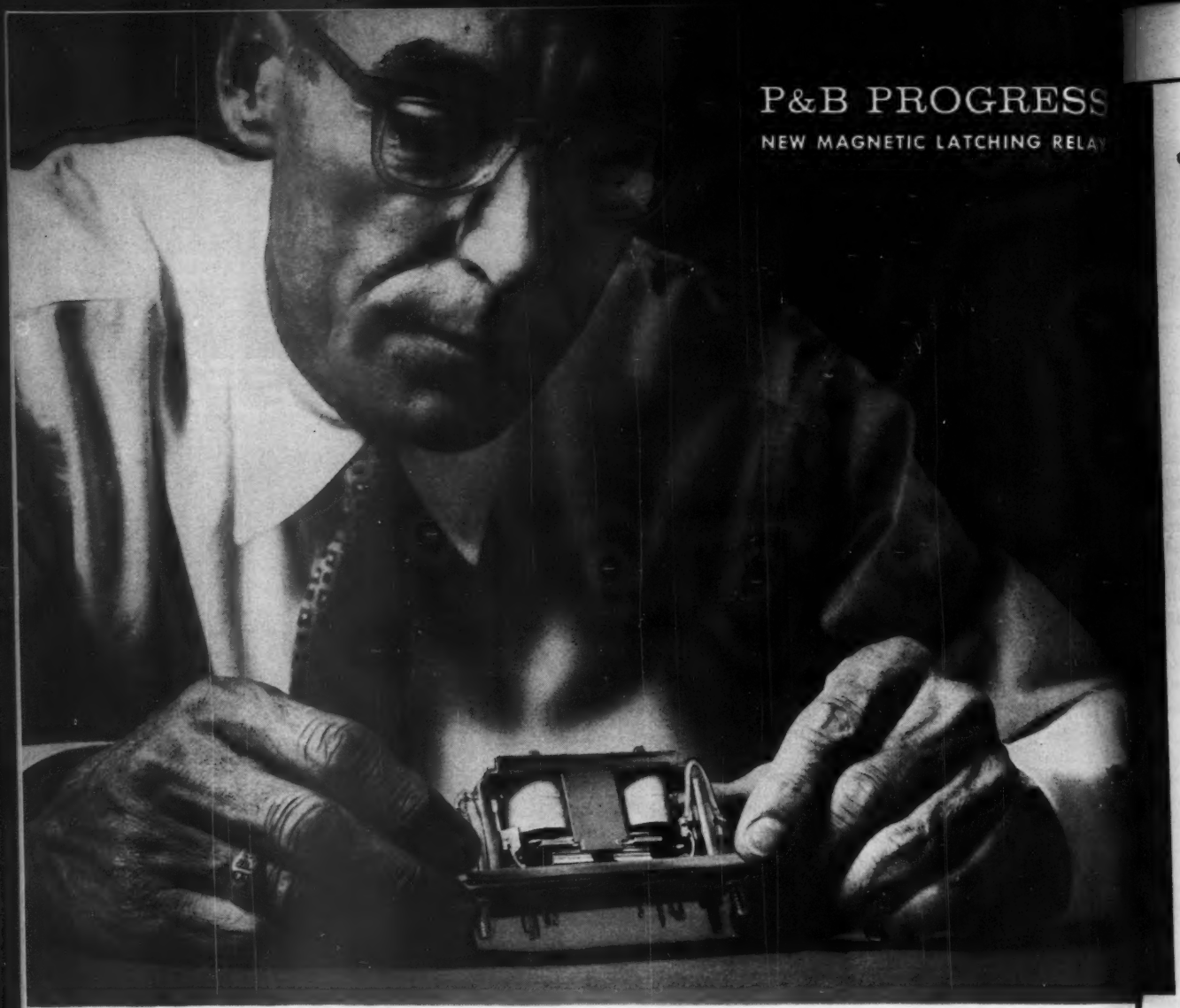
**Now in production—a new sub-miniature size.*

CAPACITORS
FANSTEEL®
RECTIFIERS

FANSTEEL METALLURGICAL CORPORATION, NORTH CHICAGO, ILLINOIS, U.S.A.

C-5113

RELIABLE TANTALUM CAPACITORS SINCE 1930



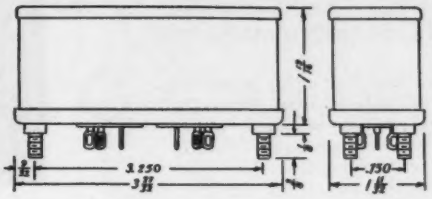
NEW RELAY SWITCHES 30 AMPS

Withstands 100g Shock* and 30g Vibration, 55 to 2000 cps.

KG11DG is an extra heavy duty DPDT *magnetic latching* relay. Its silver cadmium oxide contacts will carry 30 amperes, and the whole structure will withstand 100g shock*. Vibration resistance is 30g, 55 to 2000 cps. A permanent magnet is employed to (1) lock the armature into position, (2) accelerate armature transfer, and (3) greatly increase shock and vibration resistance. • KG23D is a 6PDT version of this relay with the contacts rated at 3 and 5 amperes. It has the same shock and vibration resistance and operates with exceptional reliability over a range of contact loads from dry circuits to 5 amperes, 28 volts AC, resistive.

**Contact openings of less than 80 microseconds.*

POTTER & BRUMFIELD, INC., PRINCETON, INDIANA/SUBSIDIARY OF AMERICAN MACHINE & FOUNDRY COMPANY



KG11DG RELAY | **KG23D RELAY**

30 AMPS	GENERAL	3 & 5 AMPS
Teflon, Glass & Ceramic.	—Insulation—	Teflon, Glass & Ceramic.
1000 megohms min.	—Insulation Resistance—	1000 megohms min.
1000 volts rms.	—Breakdown Voltage—	1000 volts rms.
100g with less than 80 micro-seconds opening.	—Shock—	100g with less than 80 micro-seconds opening.
30g from 55 to 2000 cps; .195" max. excursion from 10 to 55 cps.	—Vibration—	30g from 55 to 2000 cps; .195" max. excursion from 10 to 55 cps.
—65°C. to +125°C.	—Ambient Temperature—	—65°C. to +125°C.
13 ozs.	—Weight—	13 ozs.
12 ms. with 225 ohm coil @24V DC.	—Pull-in-Speed—	12 ms. with 225 ohm coil @24V DC.
Two 5-pin multiple solder headers. Contacts: Heavy-duty pierced solder terminals. Coils: Hook end for 3 #20 AWG wires.	—Terminals—	Two multiple solder headers with hook ends for 3 #20 AWG wires.
Hermetically sealed only.	—Enclosures—	Hermetically sealed only.
	CONTACTS	
2 Form Z. (DPDT Double make—double break)	—Arrangements—	2, 4, and 6 Form C.
30 amps @28V DC resistive.	—Load—	Dry circuits. 5 amps @28V DC resistive. 3 amps @115V AC resistive.
Silver cadmium oxide.	—Material—	Palladium (Gold-flashed for dry circuits).
	COIL	
2.6 watts approx. at nominal voltage.	—Power—	2.6 watts approx. at nominal voltage.
Either coil may be left energized without damage.	—Duty—	Either coil may be left energized without damage.
Teflon tape and Ceramic.	—Insulation—	Teflon tape and Ceramic.
Four 3/8 inch #8-32 studs on 3¼ x ¾ inch centers.	—Mounting—	Four 3/8 inch #8-32 studs on 3¼ x ¾ inch centers.

Voltage:	6VDC	12VDC	24VDC	48VDC	110VDC
Resistance:	14 ohms	55 ohms	225 ohms	835 ohms	5500 ohms

P&B STANDARD RELAYS ARE AVAILABLE AT YOUR LOCAL ELECTRONIC, ELECTRICAL AND REFRIGERATION DISTRIBUTORS

Potter & Brumfield, inc.

PRINCETON, INDIANA

SUBSIDIARY OF AMERICAN MACHINE & FOUNDRY COMPANY

Manufacturing Divisions also in Franklin, Ky. and Laconia, N.H.

Potter & Brumfield, Inc., Princeton, Indiana
Attn: T. B. White, Brig. Gen. USMC (Ret.)
Special Projects Engineer

Please send me complete data on the new KG Series relays, plus the new compact catalog of P&B standard relays.

Name_____

Company_____ Dept. No._____

Address_____

City_____ Zone_____ State_____

See our catalog in Sweet's Product Design File

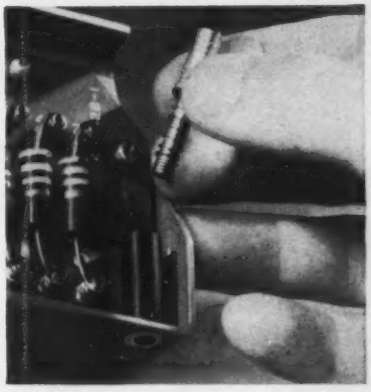
speeds up to 9,000 pieces an hour. The wire is fed, rather than pulled into cutting heads. Length of the wire is adjusted by simply changing the feed speed.

Markem Machine Co., Keene, N. H., has a rotary-offset component marking machine which features fast type change. It uses movable type held in a frame, instead of one-piece rubber printing plates.

Automatic component insertion machinery was shown by Gardner-Denver Co., Quincy, Ill., and Design Tool Corp., New York, N. Y. G-D's solderless wire-wrap machine places and wraps up to 2,000 axial lead components an hour in circuit boards, attaching both leads of each component simultaneously on terminals.

Design Tool's punched-tape programmed machine drills printed circuit boards and inserts components of up to 24 different values. If pre-punched boards are used, the drilling head may be replaced by a second insertion head. Also shown was a selective soldering machine for circuit boards.

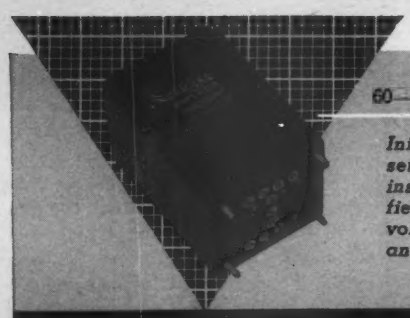
Subassembly Fastener Has No Loose Parts



Bolt is lowered into sleeve on assembly and turned twice

CAPTIVE fastener for locking subassemblies to major assemblies requires no handling of loose parts during assembly or repair and has a built-in quick detach. The fastener was designed by Northrop Aircraft, Inc., and is licensed to the Moran Co., El Segundo, Calif.

The sleeve of the fastener is



60—CPS MAGNETIC AMPLIFIER

Initial stand-off error (zero offset) of this Ferrac DC-to-DC instrument type magnetic amplifier does not exceed ±120 millivolts with changes in operating and environmental conditions.

Magnetic DC Amplifier Has High Stability and Long Life

For industrial automatic controls and ground military tracking equipment, Ferrac magnetic amplifiers provide exceptional stability. These hermetically sealed units require no bias or compensation; null balance is permanently built in. They operate directly from 115-volt 60-CPS power line. Standard units are available from current production for general purpose, thermocouple amplifier, integrators, and high gain (5 volts out for 100 microamperes in).

CHARACTERISTICS

INPUT: Two independent control windings for reversible DC.

OUTPUT: Unfiltered DC linear over the range ±7.5 volts into 1000-ohm load.

POWER REQUIREMENT: Less than 3.5 VA at 115 ±11 RMS volts at 60 ±6 CPS.

GAIN: Gains of standard Ferrac amplifiers are expressed as transresistance. To obtain output, multiply input by transresistance.

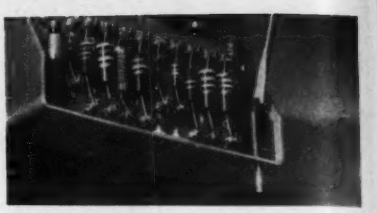
Type	Transresistance Control A	Transresistance Control B
M-5284	25 x 10³	25 x 10³
M-5267	5 x 10³	100 x 10³
M-5268	50 x 10³	50 x 10³
M-5285	5 x 10³	6.4 x 10³

Actual gains are held within ±0.2 volt of nominal values at 5 volts output and are stable within ±0.5 volt at 5 volts output with changes in ambients.

ENVIRONMENT: Ferrac amplifiers operate from −55 C to +85 C, withstand 10 G vibrations at 10 to 2000 CPS, and shocks of 30 G for 11 milliseconds along principal axes; they are hermetically sealed.

DESIGNERS AIRPAX PRODUCTS COMPANY ENGINEERS

Airpax Products Company, Seminole Division, Fort Lauderdale, Florida



Bolt, now captive, is depressed with screwdriver to mate with tap

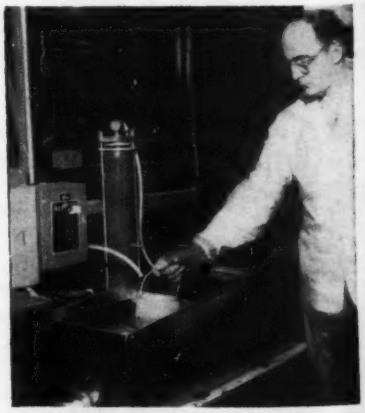
swaged in place on the subassembly frame. The bolt is threaded on its shoulder and shaft and carries a small tension spring. Two threads at the top of the sleeve accommodate the bolt's threaded shoulder.

The bolt is put in the sleeve and turned twice through the threads in the sleeve to become captive. The spring holds it in place. Pressing the bolt down exposes its threaded shaft, which is screwed into a tapped hole or mating fastener on the major assembly. The bolt tightens on a shoulder in the lower part of the sleeve.

Reversing the process detaches the subassembly. The bolt has a slotted hexagonal head, permitting screwdriver or wrench to be used.

Resin Purifies Water for Washing Cyrstals

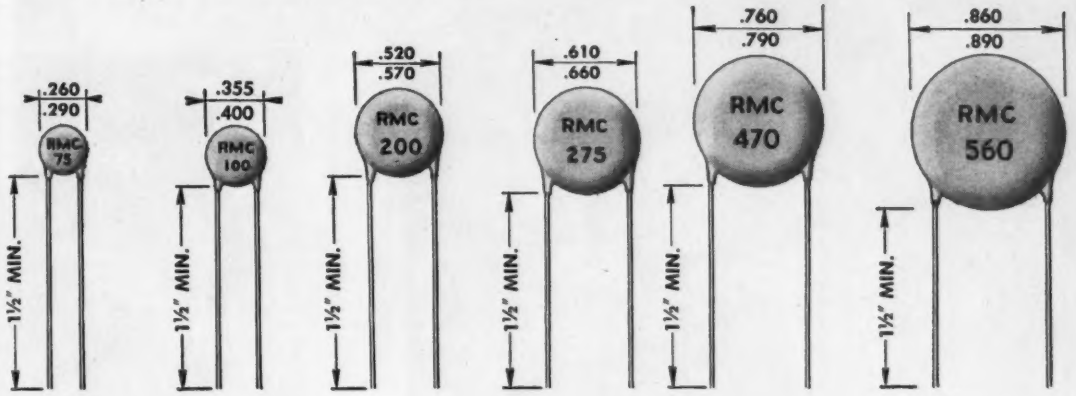
HIGH-PURITY WATER for washing semiconductor crystals and tube parts is supplied at point of use by running water through special cartridges containing resin purifiers at Western Electric's plant in Allentown, Pa. Ions are scavenged at the washing stations from deminer-



Resin water purifying unit is shown in place at a cascade washing station for electron tube parts

RELY ON RMC

for TC Capacitors



TC	1/4 Dia.	5/16 Dia.	1/2 Dia.	5/8 Dia.	3/4 Dia.	7/8 Dia.
P-100	1- 3 MMF	4- 9 MMF	10- 20 MMF	—	—	—
NPO	2- 13	14- 30	31- 69	70- 85MMF	86-115 MMF	116-150 MMF
N- 33	2- 13	14- 30	31- 56	57- 62	63-100	101-150
N- 75	2- 15	16- 30	31- 56	57- 68	69-125	126-150
N- 150	2- 15	16- 30	31- 67	68- 75	76-140	141-175
N- 220	3- 15	16- 30	31- 75	76-100	101-140	141-175
N- 330	3- 15	16- 30	31- 75	76-100	101-150	151-190
N- 470	3- 20	21- 51	52- 80	81-120	121-200	201-240
N- 750	5- 30	31- 68	69-150	151-220	221-300	301-375
N-1500	10- 51	52-120	121-200	201-270	271-470	471-560
N-2200	20- 75	76-150	151-200	201-300	301-680	—

TYPE C DISCAPS meet all specifications of the EIA standard RS-198. These temperature compensating DISCAPS are rated at 1000 V.D.C. to provide a higher safety factor than other standard or mica capacitors.

Constant production checks assure that all specifications on temperature characteristics are met. Another phase of RMC quality control consists of a 100% test for capacities.

Over the years leading manufacturers have relied on RMC for quality of product and maintenance of delivery schedules. Write today on your company letterhead for information.

SPECIFICATIONS

LIFE TEST: As per EIA-RS-198

POWER FACTOR: Over 10 MMF less than .1% at 1 megacycle. Under 10 MMF less than .2% at 1 megacycle

WORKING VOLTAGE: 1000 V.D.C.

TEST VOLTAGE (FLASH): 2000 V.D.C.

CODING: Capacity, tolerance and TC stamped on disc

INSULATION: Durez phenolic-vacuum waxed

INITIAL LEAKAGE RESISTANCE: Guaranteed higher than 7500 megohms

AFTER HUMIDITY LEAKAGE RESISTANCE: Guaranteed higher than 1000 megohms

LEADS: No. 22 tinned copper (.026 dia.)

TOLERANCES: ±5% ±10% ±20%

These capacitors conform to the E.I.A. specification for Class 1 ceramic capacitors.

The capacity of these capacitors will not change under voltage.

DISCAP CERAMIC CAPACITORS

RMC

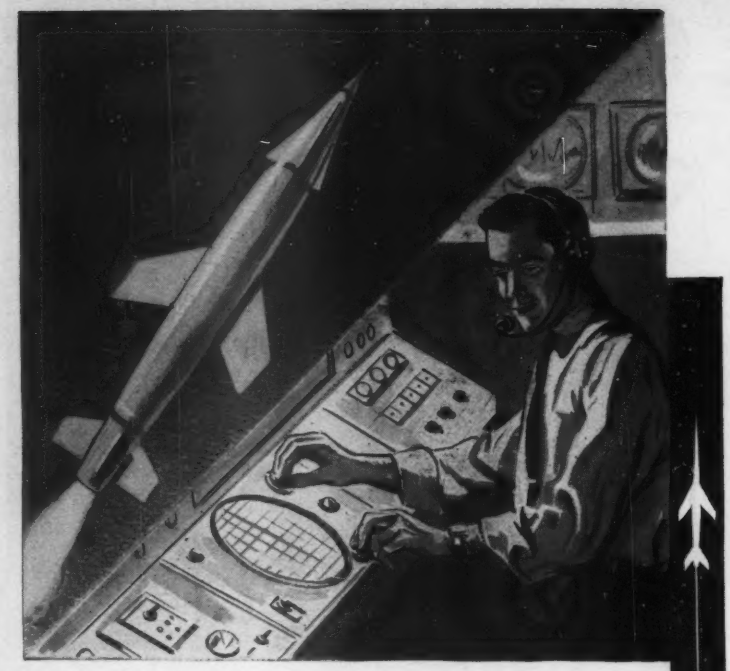
RADIO MATERIALS COMPANY

A DIVISION OF P. R. MALLORY & CO., INC.

GENERAL OFFICE: 3325 N. California Ave., Chicago 18, Ill.

Two RMC Plants Devoted Exclusively to Ceramic Capacitors

FACTORIES AT CHICAGO, ILL. AND ATTICA, IND.



• R-F RECEIVER DESIGN
• INERTIAL NAVIGATION

Two of many areas in Avionics in which Bell Aircraft has openings for qualified electronics engineers

Particularly good opportunities are now available for engineers with radio frequency experience in the 100 kilocycle to 35,000 megacycle range with emphasis on transistorizing of circuits... and for those with experience in inertial instrumentation design and evaluation.

Present openings include assignments in:

- Pulse and Digital Coding
- Identification Systems
- Electronic Counter Measures
- Landing Systems
- Digital Computers
- Precise Instrumentation Development

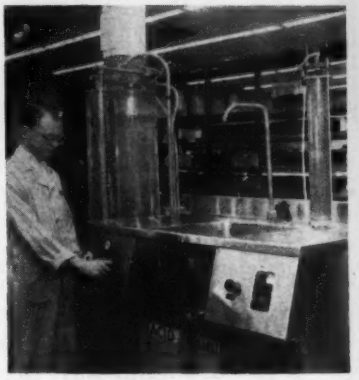
These assignments embrace a wide range of high level design and development problems which will afford full scope to your creative ingenuity with unusual opportunities for rapid advancement and professional recognition. Top salaries commensurate with your background, good living and working conditions, and liberal benefits. Please write: Supervisor of Engineering Employment, Dept. H-23, BELL AIRCRAFT CORPORATION, P. O. Box 1, Buffalo 5, N. Y.

BELL Aircraft CORP

alized water distributed from the plant's central source.

Mono-column cartridges of intimately mixed anion and cation resins, made by Penfield Mfg. Co., Meriden, Conn., have a capacity of 40 gallons an hour.

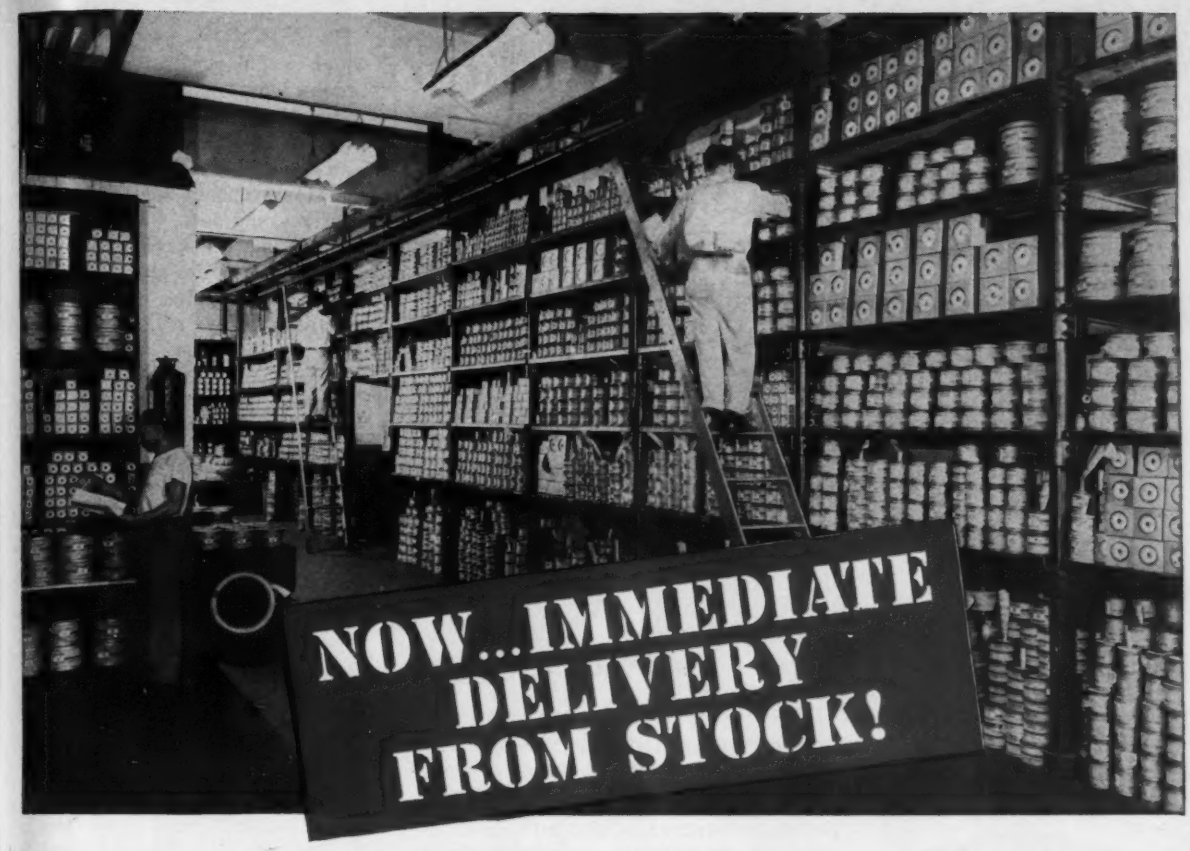
Plastic cartridge containing resin water purifiers is placed in position



Spent cartridges are regenerated semi-automatically seven at a time on companion equipment

Demineralized water is supplied to the units at a minimum resistance of 100,000 ohms. The units initially remove remaining ions so that resistance is as high as 18 million ohms. Resistance drops upon continuing use. When resistance falls to 5 million ohms, the spent cartridge is replaced. A cartridge generally lasts 1 to 2 months.

Electrical conductivity bridges continually monitor water quality. The bridges are installed in the water line to avoid inaccuracies



Orders for DRIVER-HARRIS Nickel and Nickel Alloy Wire FILLED IN 24 HOURS

If we receive your order in the morning, it will be shipped out before evening . . . this is the new service policy of Driver-Harris in the manufacture and distribution of 18 most frequently purchased Nickel and Nickel Alloys in wire form. In addition to this new warehouse stocking program, is the improved delivery schedule for Monel, Grade "A" Nickel, Inconel, R Monel and some Stainless Steels with lead time reduced to only 7 days in certain cases. The following list covers immediate availabilities. For complete detailed current listing showing all sizes and specifications, contact the nearest Driver-Harris branch — or call HUmboldt 3-4800 (New Jersey), REctor 2-9579, 80, 81, 82 (New York City).

IN STOCK READY FOR DELIVERY

MONEL	25 wire sizes from .0021 to .091
GRADE "A" NICKEL	12 wire sizes from .0025 to .091
GRADE "D" NICKEL	9 wire sizes from .005 to .015
INCONEL	3 wire sizes from .0253 to .050
STAINLESS STEEL	
Type 304	24 wire sizes from .0016 to .164
Type 316	6 wire sizes from .007 to .0135
Type 330	25 wire sizes from .0063 to .144
NICHROME*	65 wire sizes from .0007 to .289
NICHROME* V	62 wire sizes from .00045 to .289
CHROMAX*	35 wire sizes from .0031 to .258
KARMA*	36 wire sizes from .0005 to .036
ADVANCE*	49 wire sizes from .0008 to .258
MANGANIN	37 wire sizes from .001 to .1285
LOHM*	29 wire sizes from .001 to .182
MIDOHM*	28 wire sizes from .00175 to .182
30 ALLOY	28 wire sizes from .0015 to .182

LEAD TIME FOR MANUFACTURING WIRE & RIBBON

As low as 10 days for

COLD DRAWN MONEL	wire sizes from .001 to .1875
GRADE "A" NICKEL	wire sizes from .001 to .1875
COLD DRAWN INCONEL	wire sizes from .001 to .1875
R MONEL	wire sizes from .0285 to .204

As low as 7 days for

STAINLESS STEEL wire and ribbon
Types: T-302, T-304, T-305, T-316, T-430, T-446

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INCONEL & MONEL
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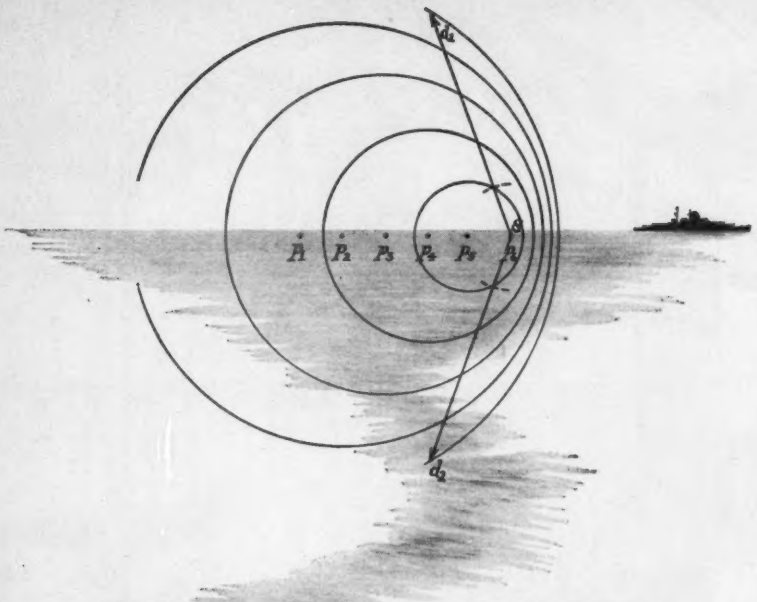
Driver-Harris Company*

HARRISON, NEW JERSEY • BRANCHES: Chicago, Detroit, Cleveland, Louisville

Distributor: ANGUS CAMPBELL, INC., Los Angeles, San Francisco • In Canada: The B. GREENING WIRE COMPANY, Ltd., Hamilton, Ontario

MAKERS OF THE MOST COMPLETE LINE OF ALLOYS FOR THE ELECTRICAL, ELECTRONIC, AND HEAT-TREATING INDUSTRIES



NEW 1E1 BANDPASS FILTER

The new Bulova 1E1 Bandpass Filters give today's radar microscopic eyes. Shaving the broad frequency range of returning signals into tiny segments, they help reconstruct signals faithfully for maximum information, for accurate measurement of Doppler effect... all at greatly reduced noise levels.

With characteristic Bulova precision, bandwidths and insertion losses are closely controlled, so that many filters may be paralleled to cover an almost unlimited frequency spectrum.

Now in production for virtually all leading manufacturers in the radar field are filter packages of 200 cps bandwidth with crossovers at the 1/2 db. point, and with insertion losses equal to within 0.3 db. from filter to filter.

Typical specification of a single filter in 10 K.C. spectrum:
Center frequency: 144.400 KC
Lower 1/2 db. point: 144.330 KC
Upper 1/2 db. point: 144.470 KC
Lower 3 db. point: 144.300 KC
Upper 3 db. point: 144.500 KC
40 db. bandwidth: less than 2 KC
Insertion loss: less than 1 db.
Ripple in pass band: less than 1/2 db.
Frequency variation of pass band: less than 10 cps over temperature range of 0°C. to +70°C.
Size: 2-9/32"W x 2"D x 1-3/8"H
Weight: less than 7 oz.

Write today for full information on Bulova's standard and custom design filters.

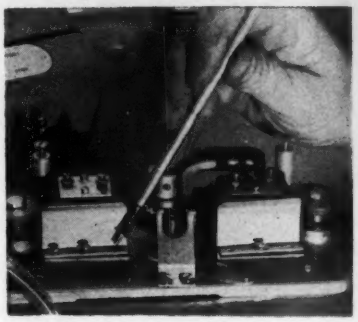
WATCH COMPANY
BULOVA
FAMED FOR PRECISION SINCE 1875
ELECTRONICS DIVISION • WOODSIDE 77 • NEW YORK

which would result from air contamination.

Spent cartridges are regenerated seven at a time in a regenerator which is also made by Penfield. The operator prepares acid and caustic solutions and sets a sequence time switch. The regenerator semiautomatically separates and regenerates the exhausted resins, reloads, rinses and tests the cartridges.

Parts are washed free of water-soluble chemical ions in cascade washers. Parts being rinsed are transferred counter-current to the flow of water.

Head of Screwdriver Spreads to Hold Screw



Expanding twin bits of screwdriver allow one-hand screw starting

SCREWS ARE GRASPED easily for starting or removal in hard-to-reach places by a new screw-holding screwdriver made by the H.J.J. Co., Oakland, Calif. The tool consists of twin steel bits which extend from a knurled brass tube 7 inches long.

To start a screw, the closed bits are inserted in the screw slot. Next, the operator pushes the tube about ¼ inch forward, forcing a pin in the tube between the bits. The pin spreads the bits and locks them in an open position.

The open bits press securely against the edges of the screw slot, allowing the screw to be held in any position without it falling off the screwdriver. After the screw is started, the tool is pulled out of the slot. The operator then brings the split bits together by pushing them out of the brass tube; a rod projecting out from the other end of the tube makes this easy to do.

New VICKERS® high current selenium rectifier saves up to 50% in space and cost...

CONVENTIONAL CELL

VICKERS HIGH CURRENT CELL

Same rating... but look at the difference in cell size! That's why the cost is lower!

The exclusive Vickers process combines improved vacuum techniques with the Vickers inorganic barrier to produce a rectifier not only with higher ratings at lower cost, but with the added advantages of

LONGER LIFE
SAFETY AT HIGHER TEMPERATURES
HIGHER OVERLOAD CAPACITY
HIGHER EFFICIENCY

Cell Ratings: 18, 22, 26, 30, 33 and 36 volts

Another typical example of cost and space savings with the new Vickers HIGH CURRENT Rectifier

TYPE OF RECTIFIER	D-C OUTPUT RATING (Self-cooled)		SPACE (Total Cell area in sq. in.)	COST (*List Price)
	VOLTS	AMPERES		
CONVENTIONAL	28	108	1620	$139.30
VICKERS HIGH CURRENT			810	$70.90

*Subject to usual quantity discount.

FREE! Bulletin 3116-1 gives detailed information on the new Vickers High Current Selenium Rectifier, including performance data, rating tables and engineering application data. Write today for your free copy and prices.

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VICKERS INCORPORATED

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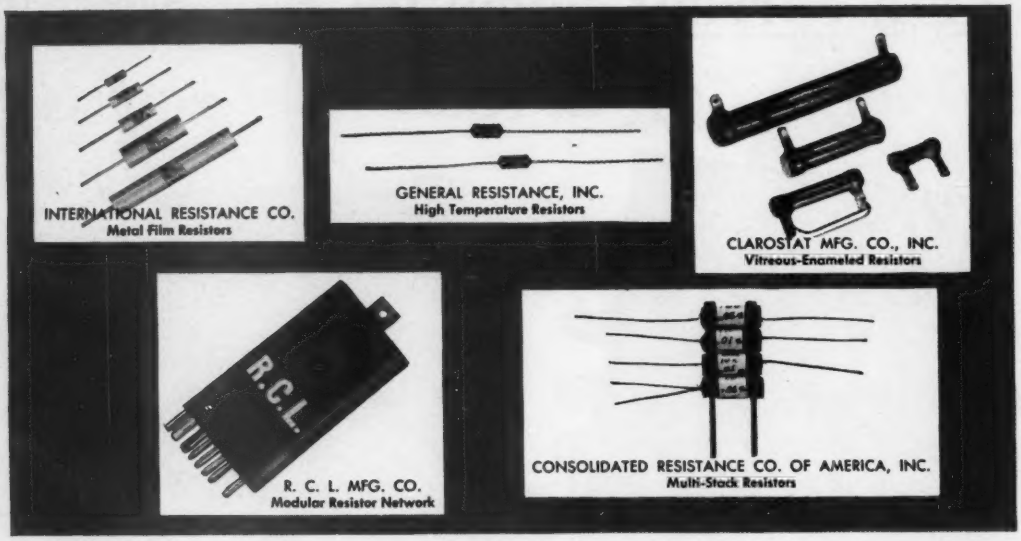
NEW PRODUCTS

Resistor Designs Make News



Offer Superior Reliability

SIGNIFICANT improvements in resistor design have been brought about to cope with severe demands made on the latest industrial and military circuits. Coatings and bonding processes make for added stability.

International Resistance Co., 401 N. Broad St., Philadelphia 8, Pa., (300), has in mass production a line of molded metal film resistors in $\frac{1}{8}$, $\frac{1}{4}$, $\frac{1}{2}$, 1 and 2-w sizes. They will withstand full load at 125 C ambient. Units have a metallic resistive film firmly bonded to a specially compounded ceramic core.

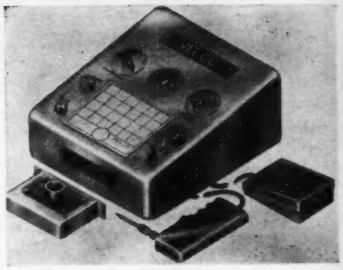
Now available from **General Resistance, Inc.**, 577 E. 156th St., New York 55, N. Y., (301), are high temperature encapsulated axial or lug-type WW resistors. Gen Res high temperature wire-wounds similar to standard encapsulated WW's, employ single length low-temperature-coefficient resistance wire reverse-wound on epoxy resin bobbins, thus effecting very low inductance factor.

R.C.L. Mfg. Co., New Jersey Ave., Riverside, N. J., (302), offers a modular type resistor network $1\frac{3}{8}$ in. long by $\frac{3}{8}$ in. wide. It has six precision wire wound resistors, completely molded with epoxy resin into one unit. Advantage here is space factor and adaptability to printed circuits.

Recently announced by **Clarostat Mfg. Co., Inc.**, Dover, N. H., (303), are the Greenohm V vitreous-enameled line which includes both fixed and adjustable resistors, with 5 w to 200 w ratings. Resistance values are from 1 ohm to 900 K ohms; standard tolerances of $\pm 5\%$ for 50 ohms and over, or $\pm 10\%$ for 49.9 ohms and under.

Consolidated Resistance Co. of America, Inc., 44 Prospect St., Yonkers, N. Y., (304), has come out with series 300 multi-stacks. The encapsulated wirewound resistor is provided with a pair of radial holes through the body for secure mounting and stacking. Mounting hardware is insulated from terminals and winding.

For more information use READER SERVICE CARD



Soldering Machine saves time, money

VIRGINIA ELECTRONICS CO., INC., River Road and B. & O. Railroad, Washington 16, D. C., announces a soldering machine that works on a new adaptation of the resistance soldering principle using a special carbon-rod electrode as one side of the circuit and the particular contact to be soldered as the other side. The carbon tip does not depend on surface area contact to transfer heat, but on contact resistance, so that the tip can be tapered to a sharp point with a corresponding increase in efficiency. A switching and indicating arrangement, controlled by means of a foot-switch, permits the soldering of only one contact at a time in any desired sequence. This feature also has the advantage of preventing incorrect

NOW standard hand socket wrench or nut-runner drives THREAD CUTTING FASTENER

Specifically designed to hold die-cast or cold-forged name plates, emblems and trim against sheet metal surfaces . . . DOT's hex-head T.C.F. can be used in many other applications which require a spring take-up fastener (with integral washer) that pulls up tight without backup on flat or contoured surfaces.

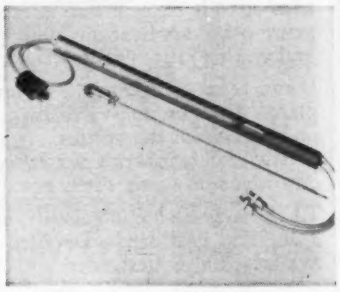
It cuts clean, deep threads on unthreaded studs, even those that are chrome plated. Used on non-vertical studs, T.C.F. accomodates itself to any angle up to 20° from the vertical . . . and, when supplied with a pre-assembled plastic sealer, makes a water-tight seal. The sealer *precedes* the fastener onto the stud so that it is not damaged by the thread-cutting process.

T.C.F. is available *in quantity*, with or without sealer, to fit 1/8", 3/16" and 1/4" studs. Detailed drawings, dimensions and prices available on request.

connections. Use of the footswitch permits the operator to maintain a continuous flow of work at all times without interruption. An adjustable temperature control and an adjustable timer prevent cold solder joints, burnt contacts and burnt insulation. **Circle 305 on Reader Service Card.**

TWT Amplifier

broadband device

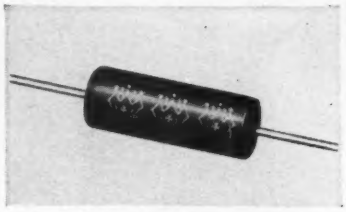


HUGGINS LABORATORIES, INC., 711 Hamilton Ave., Menlo Park, Calif. The PA-3 broadband traveling wave amplifier operates from 2.0 to 4.0 kmc without the need for electrical or mechanical adjustments.

Providing a peak pulsed output of 10 w minimum across the 2.0 to 4.0 kmc band with high gain, this device is suitable for many broadband microwave applications. Provision is made for anode modulation in such a way that any electrode may be operated at ground potential. **Circle 306 on Reader Service Card.**

Metal Film Resistor

low cost unit

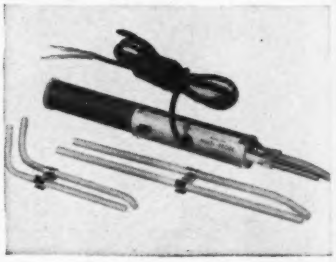


UNION RESISTOR CORP., 1001 W. Weed St., Chicago 22, Ill. Triple-Crown resistors cost only ¼ of the usual price of metal film resistors. They are made by depositing a thin film of the new Nomel alloy on ceramic. In this newly developed bonding process the film is integrally bonded to the ceramic. It is noninductive and stable to repeated overloads.

Seven types are available: ½ w units, 350 v; 1 w units, 500 v; 2 w units, 750 v. The 3, 4, 5 and 7 w units can be used at their full wattage ratings at 40 C ambient temperature. All have 1½ ± ¼ axial leads. **Circle 307 on Reader Service Card.**

Optical Tachometer

for quality control



OPTOMECHANISMS INC., 216 East Second St., Mineola, N. Y. Model 219 Multi-Probe is a new universal optical tachometer for use with any standard oscilloscope. It obtains velocity and repetitive readings without physical coupling from otherwise inaccessible places. Using the principle of reflected light, optical paths and photoelectric cells, its many applications make it an extremely versatile piece of test equipment. **Circle 308 on Reader Service Card.**

Tiny Power Supply

isolated type

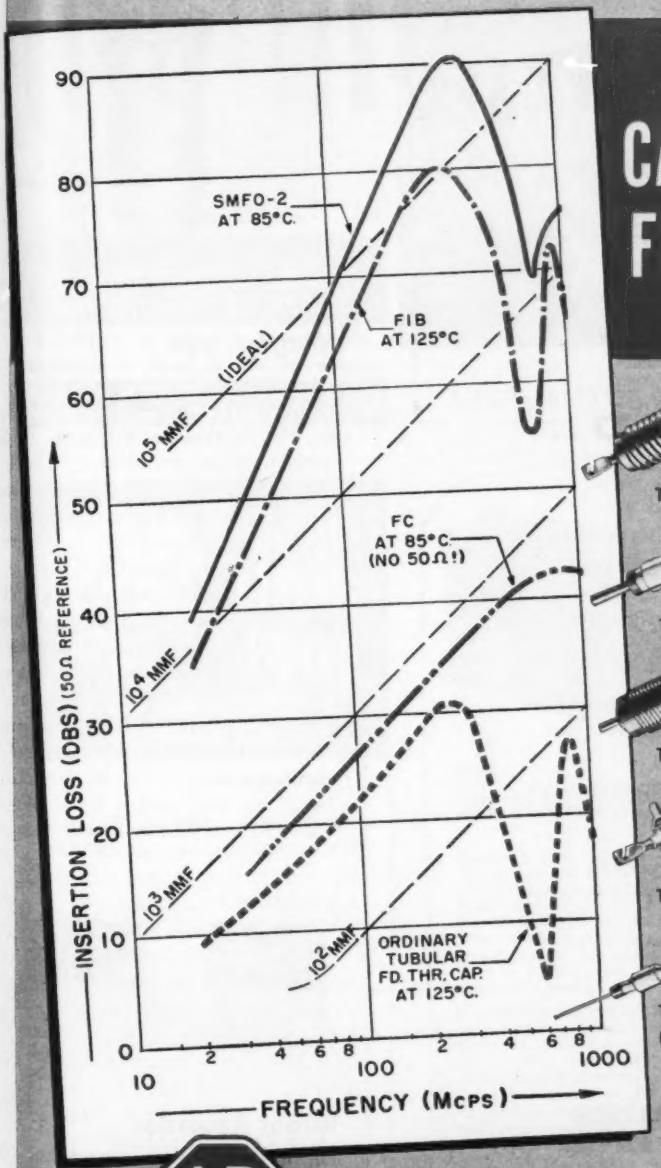
ELCOR INC., P.O. Box 354, McLean, Va. Measuring only ⅞ in. by 1⅛ in. by 2½ in. and weighing less than 3 oz, a new isolated power supply furnishes enough regulated and filtered d-c power for the collector circuit of a transistor. Alternatively, it may be used as a source of bias for transistor or vacuum-tube circuits. Various models of these inexpensive Zener-diode regulated Isoplys are available with input for 60-400 cps a-c, and with d-c output voltages ranging from 4 v to 26 v and current ratings ranging from 9 ma at 4 v to 1½ ma at 26 v.

Shunt capacitance from output to ground is only 20 $\mu\mu$f, making the supply useful as a means of direct coupling in high-speed circuits, and in many bridge circuits in which a signal voltage appears between the power supply output and ground. Leakage resistance to ground exceeds 10,000 megohms. Special shielding reduces the noise

a new idea

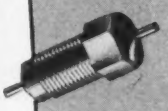
in the elimination of high frequency radiation

ALLEN-BRADLEY
CASCADED CERAMIC FEED-THRU FILTERS
(PATENT PENDING)



TYPE **FIB**

TYPE **FIS**



TYPE **FCD**

TYPE **FC**

TYPE **SMFO**
(FULL SIZE)

NOW . . . out of the Allen-Bradley research laboratories comes a completely new and far more effective line of high frequency filter elements . . . especially designed to eliminate radiation from low power circuits operating in the frequency range from 50 mcs to 5000 mcs.

Employing an entirely different concept, these new filter elements have a phenomenal filtering efficiency . . . that actually *increases* tremendously with frequency, as illustrated in the graph at left.

These filter elements display none of the detrimental internal resonance characteristics of standard tubular capacitors . . . and cascading elements permit an increase in effective capacity far beyond that practical even with discoidal design.

Filters are available in voltage ratings up to 500 v, DC at temperatures up to 125°C. Max. RF current is 0.25 amp, and max. DC or low frequency current is 5 amp.

Technical information available upon request.

A-B QUALITY

ALLEN-BRADLEY
ELECTRONIC COMPONENTS
QUALITY

Allen-Bradley Co., 1315 S. First St., Milwaukee 4, Wis. • In Canada—Allen-Bradley Canada Ltd., Galt, Ont.

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by limitations to his creativeness and encouraged to continually increase his professional stature, the engineer of Vitro's Silver Spring Laboratory is able to make increasingly important contributions in the fields of guided missile and underwater weapon systems.

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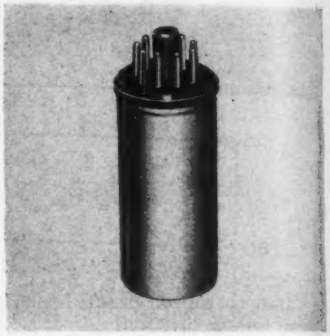
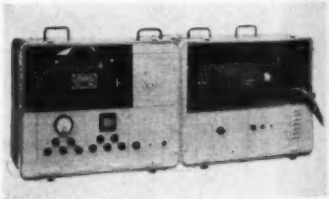
Vitro LABORATORIES
Division of the Vitro Corporation of America

in ungrounded applications to the negligible value of 1 μv per kilohm impedance to ground. No-load to full-load regulation is 2 percent, and regulation for an input voltage change of 10 percent is 1 percent. Output ripple is less than 5 mv rms. **Circle 309 on Reader Service Card.**



Input Transformer plug-in type

THE UNITED TRANSFORMER CORP., 150 Varick St., New York 13, N. Y., announces its new P-16 plug-in input transformer ideally suited for matching amplifiers to microphone and line sources. This P-16 transformer has a center tapped primary suited to 150, 200, 250, 500 or 600 ohm sources, and provides a stepup to grid impedance ratio of 200:1. Frequency response is within approximately 1 db from 30 to 20,000 cycles. Two heavy gage high permalloy shields effect very low hum pickup. The case dimensions are 1 3/16 in. diameter by 2¾ in. high with a 9-pin plug. **Circle 310 on Reader Service Card.**

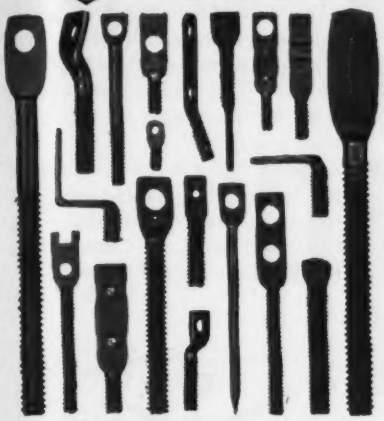


Radar Recorder films pps, sector scan

ALTO SCIENTIFIC CO., 855 Commercial St., Palo Alto, Calif. A new airborne radar recording unit permits radar presentations to be filmed in a manner enabling play-

SINCE 1920 QUALITY WENCO PRODUCTS

SPADE BOLTS



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WIRE STRIPPERS & CUTTERS

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ULTRA LOW capacitance & attenuation

TYPE	μμF/ft	IMPED.Ω	O.D.
C 1	7.3	150	.36"
C 11	6.3	173	.36"
C 2	6.3	171	.44"
C 22	5.5	184	.44"
C 3	5.4	197	.64"
C 33	4.8	220	.64"
C 4	4.6	229	1.03"
C 44	4.1	252	1.03"

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CIRCLE 133 READERS SERVICE CARD

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ON ANY PART— TO ALL SPECS

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new...improved

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FEATURES

- Recently developed high-contrast viewing screen for utmost visual sharpness!
- Digit style of your choice!
- Colored digits of your choice! Suitable to environmental ambient room light.
- Digital presentation complementing manufacturer's original equipment!

WITH ONE PLANE PRESENTATION

Here's a new type of In-Line Digital Display. All numbers and/or characters appear on the front surface of the unit, and are of uniform size and intensity. In addition to being faster and easier to read, the numbers may be quickly seen from any angle of viewing.

The In-Line Display is available as a single unit, or in assembled groups of two, three, four, etc., ready for panel mounting. The viewing screen extends the full width of the individual unit so that the final assembly presents a continuous surface for fast, easy reading.

PRICE PER UNIT $15.50

QUANTITY PRICES ON REQUEST

HOW THE EIE IN-LINE DIGITAL DISPLAY OPERATES

The In-Line Display works on a rear-projection principle. When the lamp (A) at rear of the unit is lighted, it projects the corresponding character on the condensing lens (B) through a projection lens (C) onto the viewing screen (D) at the front of the unit.

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FXC presents a comprehensive line of

threaded ferrite slugs

for permeability tuning

Ferrites are the finest material for tuning slugs wherever a high-Q, high-permeability core is required and space is at a premium. These Ferroxcube tuning slugs have been specifically developed for the permeability tuning of inductors, filters and transformers in the 1 kc to 4 Mc frequency range. They come in a large variety of sizes and threads, and have been found particularly useful for final inductance adjustments on filters with ferrite pot cores. The screwdriver slot in the slugs runs all the way through the core for simpler coil assembly and easy adjustability at either end. All Ferroxcube threaded slugs are furnished complete with self-threading coil forms of phenolic-impregnated tubing.

For complete data, as well as information on the availability of specific types and sizes, write to:

FERROXCUBE CORPORATION OF AMERICA
50 East Bridge Street, Saugerties, New York

Manufacturers of ferrite cores for recording heads, magnetic memories, TV flyback transformers, pulse transformers, filters, inductors, high frequency shields and power transformers

back through grid display consoles.

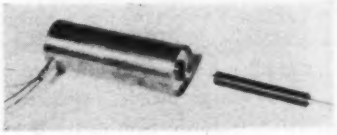
Providing for both sector scan and ppi presentation, the unit employs a modified indicator whose trace is photographed by a servo-driven, nonintermittent 35-mm camera. The unit includes provisions for monitoring the recording trace brightness.

The recorder is self-contained in two lightweight, portable cases each measuring approximately 20 in. by 26 in. by 15 in. deep. **Circle 311 on Reader Service Card.**

Hook-Up Wire for high temperature

TENSOLITE INSULATED WIRE CO., INC., 198 Main St., Tarrytown, N. Y., has developed a new method for insulating high temperature miniature wire and cable. Most significant feature of Flexolon wire is color guard striping. This means that the stripe, clearly visible and identifiable is protected by a thin layer of highly abrasion-resistant Teflon.

By means of the new Flexolon method minimum continuous lengths of 250 ft are guaranteed; with average continuous production lengths running between 750 and 1,000 ft. **Circle 312 on Reader Service Card.**



High-Output Coil with double range

AUTOMATIC TIMING & CONTROLS, INC., King of Prussia, Pa., has developed a differential transformer

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Crystal Can Relay

Hermetically sealed, fast and sensitive. Withstands extreme temperatures, shock and vibrations. Plug-in, solder-hook and 3-in. lead type available. Meets military specification MIL-R-25018, MIL-R-5707C except as to contact overloads

We maintain complete distributor stocks of the following makes:

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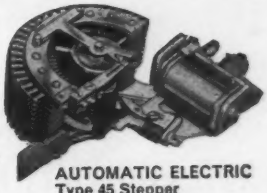
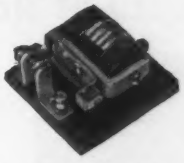
Relay Sales cannot get better delivery from manufacturers than you. Relays now in stock were ordered as long as 10 months ago and selected by men who have specialized in supplying relays to the industry for many years. The items illustrated are typical of hundreds of thousands in stock. They are available in all popular coil ratings and contact arrangements. Why wait for relays? Call us today!



AUTOMATIC ELECTRIC
Type 45 Stepper
Wide Selection



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Keying Relay
Many Types in Stock

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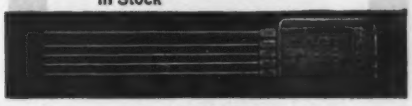
9QA Midget for Sub Chassis Mounting. Many Others in Stock



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IERC HEAT-DISSIPATING ELECTRON TUBE SHIELDS

— AND EQUIPMENT "DOWN TIME" LOSSES CAUSED BY HEAT, SHOCK AND VIBRATION!

Investigate the extraordinary tube-saving, cost-saving potentials of IERC Heat-dissipating Tube Shields — the only complete, commercially-available line of effective heat-dissipating electron tube shields for **miniature, subminiature and octal/power** size tubes. IERC's expanded line of heat-dissipating tube shields for the larger size power tubes offer, for the first time, **a practical method to retain these tubes** in severe shock and vibration environments!

The most complete electron tube heat-dissipation information is yours for the asking! Technical data comprised of IERC and independent laboratory test reports will be sent upon request on your company letterhead.

CROSS-LICENSED WITH NORTH AMERICAN AVIATION, INC.
PATENTED OR PATS PEND.

International
electronic research corporation
145 West Magnolia Boulevard, Burbank, California

LATEST addition to IERC's product line is the IERC HEAT DISSIPATOR for POWER TRANSISTORS. Effective reduction of temperatures, elimination of heavy, large or finned surfaces plus adaptability for use in confined spaces are prime features. Technical Bulletin PP112 is included with general IERC information sent on request.

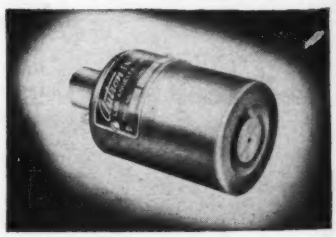
Heat-dissipating electron tube shields for miniature, subminiature octal and power tubes

that features a double range and low null.

This new coil has an input of 120 v 400 cps and an output of 50 v into 10,000 ohm load. Special construction permits a phase angle shift of only 2 deg from null to maximum displacement. The short range specifications are ± 0.125 in. with 2 in. long armature having 0.330 in. o-d and 0.127 in. i-d; the longer range, ± 0.250 in. with 2.5 in. long armature having 0.330 in. o-d and ⅞ in. i-d. **Circle 313 on Reader Service Card.**

Instrument Ovens to user's specifications

THERM-O-LAB CORP., 6940 Farmdale Ave., North Hollywood, Calif., offers a wide variety of instrument ovens with virtually off-the-shelf delivery. Because the Therm-O-Lab element is used extensively in this application the company has decided to offer the units complete to the customer's specifications. The inorganic film type element offers a greater degree of efficiency, which is reflected in lower power consumption or faster heat up, and being an area heater it offers virtually perfect uniformity of heat distribution. **Circle 314 on Reader Service Card.**

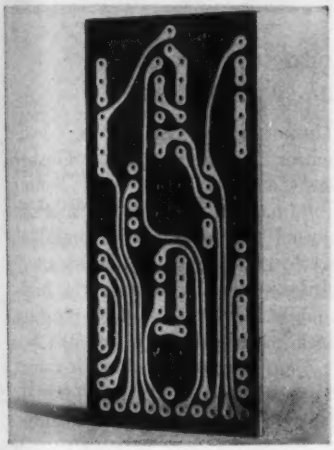


Sensor Unit for sorting, counting

AUTRON ENGINEERING, INC., 1254 West Sixth St., Los Angeles 17, Calif. A new sensor unit, designed

for sorting and counting, responds to the presence of all metallic and most nonmetallic materials. Within limits, the unit will detect a $\frac{1}{16}$ in. change of position of metallic parts. Model 6120 proximity detector can also be used for limiting, warning and process control and gaging, when used in conjunction with the model 6330 controller.

Response rate of 400 ppm gives the unit a high speed capacity. Output is nominally 5 v d-c across a 5 megohm load. Metallic material within $\frac{1}{2}$ in. of the detector's face produces a 15 percent signal. **Circle 315 on Reader Service Card.**



P-C Boards copper-metallized

Corning Glass Works, Corning, N. Y., has available copper-metallized printed circuit boards designed for missiles, communication systems, control and measuring instruments, radar and other high reliability units.

Automatically produced, the new boards are made of Fotoceram, a chemical machinable glass with a flexural strength of 25,000 psi, and have through-hole plating. The boards are capable of continuous operation at 250 C without sagging or warping, even in the most adverse environmental conditions.

The $\frac{1}{8}$-in. runs and through-hole plating of the boards show no indication of blisters, lifting or any metal failure after a solder pot immersion of five minutes at 500 F. The high, base-to-metal strength of the new circuit boards permits repeated soldering of components

No. 89

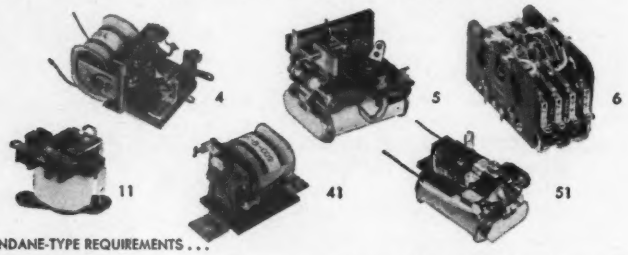
"BUILDING BLOCK" APPROACH SPEEDS SYSTEM DEVELOPMENT
Based on extensive experience in system development, Hallamore has designed DC Amplifier HEC-0142, for wide application in "building-block" type instrumentation systems. Combining high stability, broad bandwidth, with low noise and drift characteristics, the amplifier, one of the series of Hallamore "building-blocks," is designed to save initial development time, as well as to simplify functional changes or replacement of units within a system. Write for complete information on HEC-0142 and the "Building-Block Instrumentation Series": Dept. 15J, 8352 Brookhurst Avenue, Anaheim, California. TWX Code: ANH-9079.
HALLAMORE ELECTRONICS COMPANY
A division of The Siegler Corporation

SIGMA TYPES AT YOUR SERVICE

On the left, Hardwicke J. von Cumulus exemplifies scientific inquiry in the best tradition, pondering problems of the highest order concerning interrelation of theoretical factors in sensitive relay design. His is an 0.6^{-13} world, beyond the ken of most, deaf to the Cry of the Coliseum. He's the gentleman to see if you're just wondering about the characteristics of a relay for use somewhere out of this world.

At right is Sigma's General Purpose Application Man of the Year, Mackinaw L. Mundane. Although Mackinaw will never quite understand what all the Hardwickes are muttering about, he doesn't care; he's closing in fast on some good unsophisticated jobs for Sigma relays. He's heard all about Progress, Improvement and Doing the Difficult Jobs Well, but he knows *his* bread is buttered by the guy who wants a relay that will work well, on the ground, under everyday circumstances. He will enthusiastically tell you, point blank, which Sigma type to pick for speed, quietness, price, life or some combination thereof. His customers make toys, burglar alarms, electric blanket controls, machinery controls, UL-approved items and such, and some of his favorite relays are shown below.

Actually, there's a whole crew of Mundanes here ready to jump when you speak — not at you, but up with answers. Or from a distance you can get some useful data on which to judge and select, in the form of specific relay Bulletins, or assembled within elegant covers as the NEW Sigma Catalog. Communication with H. J. von C. and other Scientists, however, is restricted to 8:30-5:00, Monday through Friday.



AMONG MUNDANE-TYPE REQUIREMENTS . . .

LOW PRICE: Series 11 sells at less than a dollar in quantity, with mechanical life of 100,000,000 operations. DC and shaded pole AC.

RANGE OF ADJUSTMENT: Series 4 and 5 can be adjusted and specified as to both drop-out and pull-on. Standard sensitivities from 1 to 200 mw.

HIGH CONTACT RATING: Series 51 switches 10 amperes of incandescent lamp load yet operates on 100 mw.

HIGH SPEED: Series 41 can be operated in less than 2 milliseconds and will switch loads up to 1 ampere 100,000,000 times.

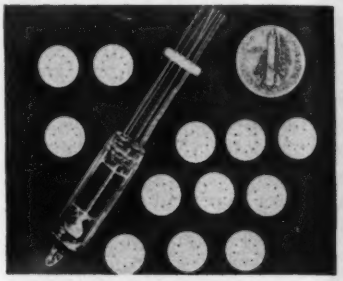
AC OPERATED: Shaded pole 41 with no rectifiers. Extremely quiet, reliable operation with switch ratings up to 5 amperes, or operating sensitivity as low as 0.06 v-a.

MAGNETIC LATCHING: Series 6 (Form Z) polar relay provides an exceptionally reliable latching contactor. Up to 4-pole double throw with no mechanical catches to wear.

SIGMA

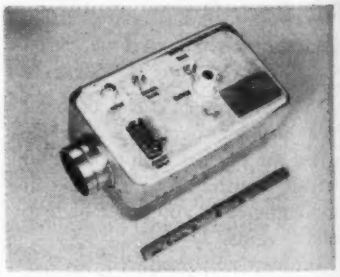
SIGMA INSTRUMENTS, INC.
62 Pearl Street, So. Braintree 85, Massachusetts

without damaging the copper runs. On test, components have been resoldered to the same run more than 20 times without any indication of run failure. **Circle 316 on Reader Service Card.**



Lead Insulators for subminiatures

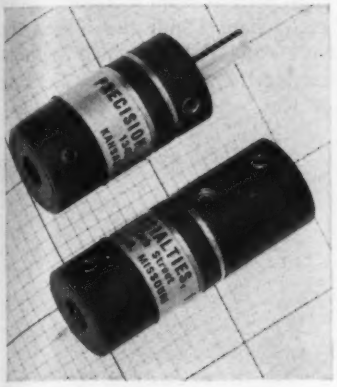
FLUOROCARBON PRODUCTS, INC. division of United States Gasket Co., Camden, N. J. New Teflon subminiature tube lead insulators now offered answer the demand of missile guidance and military electronics systems producers for high reliability factor — withstanding shock, vibration, heat (to 500 F), zero moisture absorption, low-loss characteristics (less than 0.0005). **Circle 317 on Reader Service Card.**



R-F Amplifier with built-in blower

TELECHROME MFG. CORP., 28 Ranick Drive, Amityville, L. I., N. Y., presents a small and rugged 100 w telemetering amplifier, only 2 w drive. Measuring only 3¼ in. by 4 in. by 6½ in., this new r-f amplifier covers the range 215 to 260 mc and operates under all missile vibration, acceleration and heat conditions. A built-in blower allows operation at temperatures up to 125 C.

Model 1466 r-f amplifier may be driven by such 2 w transmitters as the model 1472-A f-m/f-m or pdm/f-m telemetering transmitters. **Circle 318 on Reader Service Card.**



Slip Clutch
two mounting types

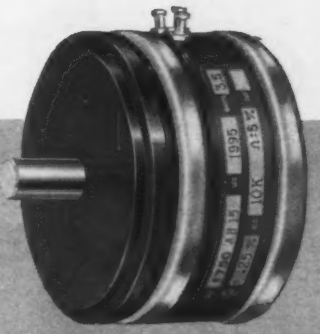
PRECISION SPECIALTIES INC., 1342 E. 58th St., Kansas City 10, Mo., has available a new slip clutch in two mounting types. They measure only ¾ in. in o-d by 2 in. long, require no lubrication, and are easily adjusted to transmit from 0 to 4 in.-lb of torque. They provide the economical answer to many in-line slip clutch or overload coupling problems. **Circle 319 on Reader Service Card.**

Pulse Analyzer
priced at $9,850

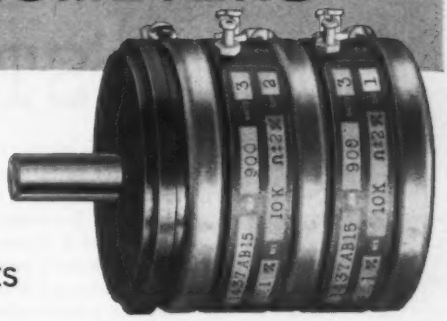
TECHNICAL MEASUREMENT CORP., 140 State St., New Haven, Conn., manufactures an accurate 100-channel pulse height analyzer. Model PA-100 features quartz de-

A New Complete Line

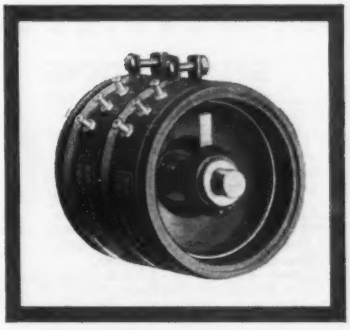
...COMPETITIVELY PRICED
...ONE OR THOUSANDS
...SINGLE OR GANGED



GIANNINI
Precision
POTENTIOMETERS



Ready for rapid delivery...meet rigid requirements



"Giannini Technical Notes" announces various instruments and controls which are available for 24 hour delivery.

ITEM:
Model 1437 (NAS-710, style RRI5)
RESISTANCE: 100 to 160,000 Ω
LINEARITY: 0.5% to 0.1%
RESOLUTION: to 3900 wires

ITEM:
Model 1750 (NAS-710, Style RRI8)
RESISTANCE: 100 to 300,000 Ω
LINEARITY: 0.5 to 0.1%
RESOLUTION: to 5,000 wires

ITEM:
Other Models from ⅞" to 3" diameter. Ganged units are externally phaseable.

Giannini measures & controls:

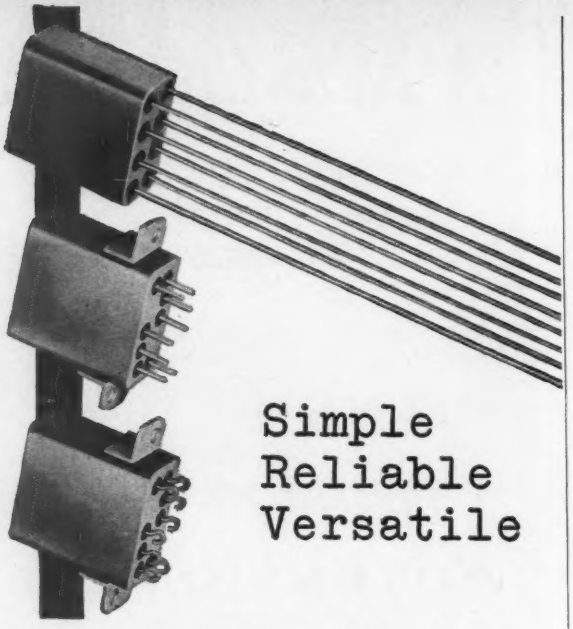
ω	β	θ	ψ	τ	v	φ
δ	Ω,	ω	h	P	ΔP	T
T_0	P_0	Q_E	M	T_0	P_y	TAS

PRECISION INSTRUMENTS AND CONTROLS
Giannini

G. M. GIANNINI & CO., INC., 918 EAST GREEN STREET, PASADENA, CALIF.

NEW LIGHT-WEIGHT

Micro-miniature Relay

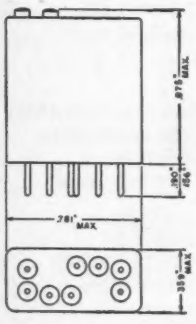


Simple Reliable Versatile

HUSKY STYLE 6

Price Electric's new Style 6 micro-miniature relay is a lightweight, crystal can style relay designed to give superior performance in miniaturized assemblies.

Weighing only 0.5 ounce, the Husky Style 6 is engineered for the utmost simplicity—a simplicity that allows for mass production of a high quality, reliable relay that is as versatile as it is dependable. Termination can be provided to meet most requirements. Style 6 meets the applicable requirements of military specifications and will perform continuously in ambients of −65C to +125C. This tiny Husky Relay will give excellent performance in guided missiles, computers, control systems, and other critical applications.



SPECIFICATIONS

Ambient Temperature: −65C to 125C.
Coil Data—Supplied with 920 ohms ±10% for 26.5 VDC nominal operation. Coils, with different resistance values, are available for other voltages.
Contact Arrangement—DPDT
Contact Rating—2 amps. at 26.5 VDC or 115 VAC resistive.
Contact Resistance—0.05 ohms max.
Dielectric Strength—1,000 volts RMS to case, 500 volts RMS across open contacts.
Enclosure—Hermetically sealed.
Insulation Resistance—10,000 megohms minimum at 25C. 1,000 megohms minimum at 125C.
Life—Minimum expectancy 100,000 operations.
Military Specifications—Meets applicable portions of MIL-R-25018 and MIL-R-5757C.
Mounting—All popular types or styles available.
Operate and Release Times—5 millisecond maximum.
Shock—50 G for 11 milliseconds.
Terminals—Plug-in, solder and printed circuit types.
Vibration—10 to 55 cps at 0.120" double amplitude. 55 to 2,000 cps at 20 G acceleration.
Weight—0.5 oz.

PRICE ELECTRIC CORP., FREDERICK, MD. HUSKY RELAYS & CONTROLS ®

For further details write for: BULLETIN NUMBER 10

Price Electric CORPORATION

1500 Church St., Frederick, Maryland

lay line data storage which contributes to its simplicity, dependability and price.

The readout of data is accomplished by a printer that records both the channel number and pulse counts decimally on paper tape. This permits rapid identification of each channel and also allows the spectrum to be scanned without erasing the storage. **Circle 320 on Reader Service Card.**

Linear Amplifier compact, shielded

TRANSITRON, INC., 186 Granite St., Manchester, N. H. The Vantron 300 linear amplifier is a compact, fully shielded unit capable of high power operation on c-w, a-m and ssb. It features a minimum number of tuning adjustments, requires little driving power, and has a heavy duty power supply.

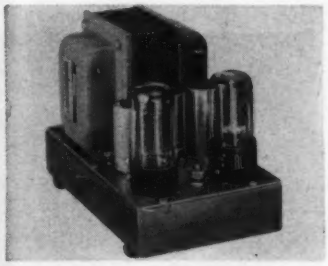
Only readily replaced tubes are used. The unit has no plug-in coils and its continuously tuned plate circuit is designed to match 50 to 100 ohm antennas. Field tests indicate it to be of low harmonic output, free from parasitics, and with excellent stability on all bands. **Circle 321 on Reader Service Card.**

Copper Oxide Diode miniaturized

BRADLEY LABORATORIES, INC., New Haven, Conn., announces model CX7A1H for low voltage, low current applications in control, instrument, computer and pulsing circuits.

The unit is insulated by nylon tube housing, $\frac{3}{8}$ in. long with $\frac{1}{16}$ in. o-d, through which leads are inserted. Specifications for instrument use are: current rating of 2 ma continuous duty, a-c input 6

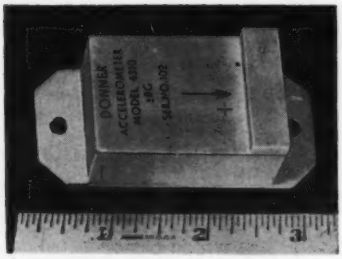
v rms maximum, peak inverse of 8½ v maximum. For other applications, the current value can be increased 5 times and voltage value doubled. Maximum temperature rating is 85 C. **Circle 322 on Reader Service Card.**



D-C Power Supplies two new types

TRANS ELECTRONICS, INC., 7349 Canoga Ave., Canoga Park, Calif., has added two more versatile power supplies for use in laboratory, test bench or original equipment. Models RS-205 and RS-305 are of modular type mounting design, rugged packages for chassis or subchassis use—for compound use—and can be ordered for rack mounting application.

Output for model RS-205 is 150-225 v d-c at 50 ma continuous duty; for RS-305, 225-325 v d-c at 50 ma. **Circle 323 on Reader Service Card.**



Accelerometer is transistorized

DONNER SCIENTIFIC CO., 888 Galindo St., Concord, Calif. Model 4310 completely transistorized precision linear servo accelerometer is available in ranges from ±0.05 g to ±50 g. Maximum output is either ± 7.5 v or ± 1.5 ma, eliminating auxiliary amplifiers required by

32-TO-1 TAPE SPEED RATIO

Includes six standard speeds from 1⅞ to 60 in/sec., giving recording time as long as 12 hours or frequency response as high as 100,000 cycles per second.

AMPEX PRECISION REELS

in 10½ or 14-inch diameters assure perfect guidance and winding even on thin 1-mil Mylar* tapes.

UNIFORM TAPE TENSION

from one end of the reel to the other is assured by newly designed servo holdback system.

FOUR INTERCHANGEABLE AMPLIFIERS

are available for each track. NRZ digital amplifiers have been added. Others are Direct, FM Carrier, and PDM (Pulse Duration Modulation).

DRIFT-FREE AMPLIFICATION

(1% or less on FM carrier) is achieved by larger blower and pressurized cooling through each amplifier.

FRONT-ACCESS OPTION

available as a standard modification will permit recorders to be built in against walls as in instrument vans, ships, etc.

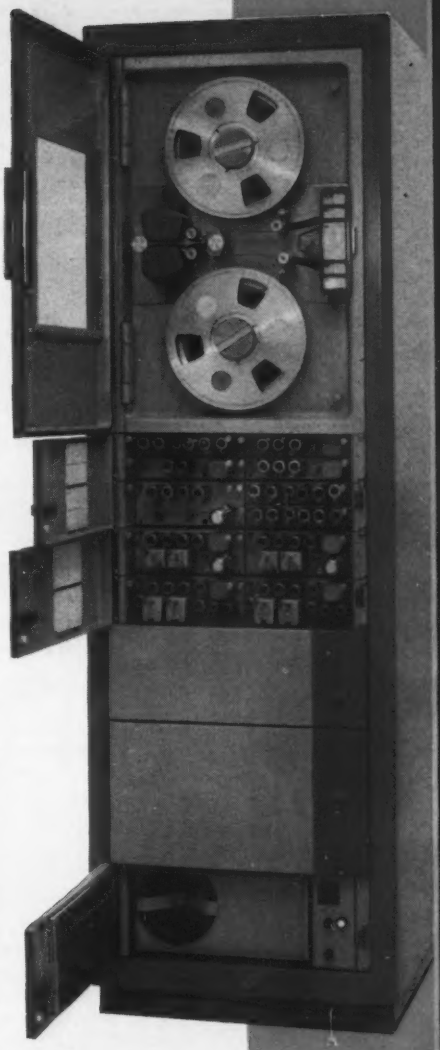
ACCESSORIES

include footage counters, remote control panels, rack dollies, head switches, new meter panels and additional plug-in options.

SPECIFICATIONS

are the most complete and meaningful ever published on any instrumentation recorder. Graphs give performance throughout wide ranges of conditions and parameters. And every FR-100A is checked out to equal or exceed stated performance.

*DU PONT TRADEMARK



NEWEST AMPEX THE FR-100A

Versatile magnetic tape recorder for data and control

Here is certainty for sale—the surest and best answers to your future data recording and processing needs. Starting with the world's most widely accepted instrumentation tape recorder, Ampex has added mechanical and electronic improvements, new accessories and more modular options. The best is made even better in performance, reliability and versatility. *For technical information, write Dept. E-100A*

INSTRUMENTATION DIVISION AMPEX CORPORATION

FIRST IN MAGNETIC TAPE INSTRUMENTATION

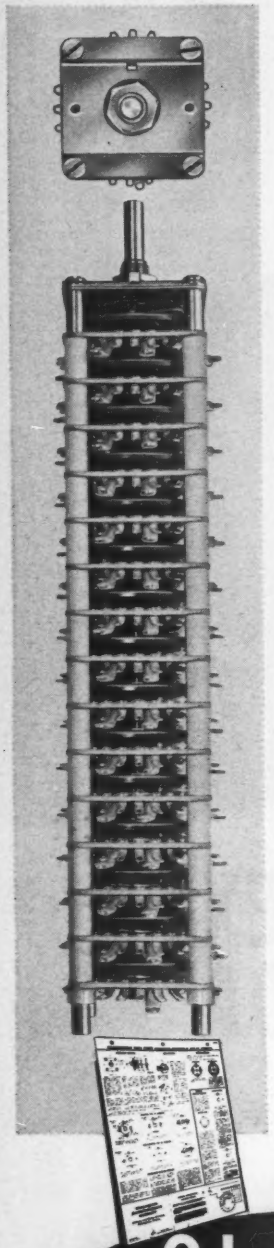
934 CHARTER STREET · REDWOOD CITY, CALIFORNIA

Phone your Ampex data specialist for personal attention to your recording needs. District offices serve the United States and Canada. Foreign representatives cover the free world.

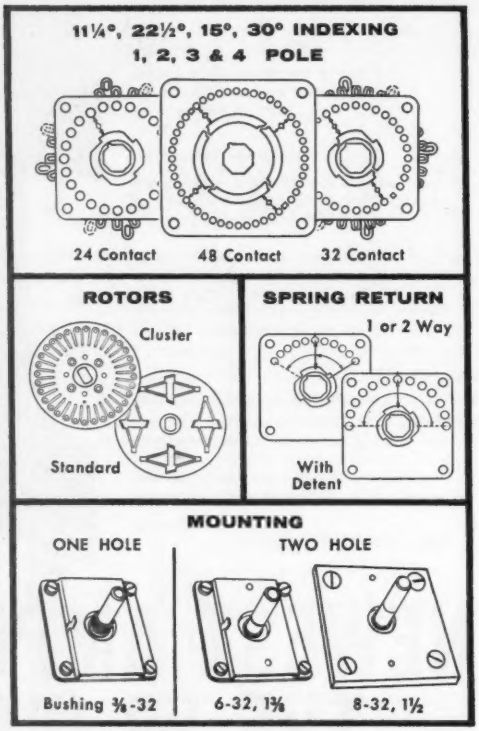
CIRCLE 98 READERS SERVICE CARD

NEW Compactness . . . *NEW* Versatility in

ROTARY SWITCH DESIGN



SHALLCROSS *Miniature* ROTARY SELECTOR SWITCHES give the long-lasting dependability of multi-leaf wiper, button-contact design . . . *and* the added advantages of compactness and new versatility. The sketches below detail some of the many unusual features of this new switch series . . .



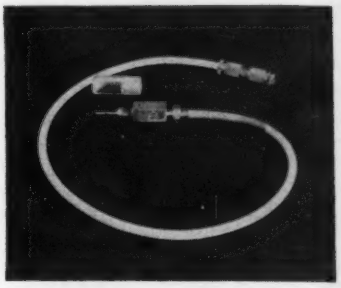
ELECTRICAL SPECIFICATIONS: Operating Voltage—to 2000 volts; Breakdown Voltage—to 3000 volts; Breaking Current—5 amp @ 125 V. ac.; Carrying Current—15 amp.

Write for complete specifications on the new Shallcross "Miniature Series".

Shallcross

SHALLCROSS MANUFACTURING COMPANY, 522 Pusey Avenue, Collingdale, Pa.

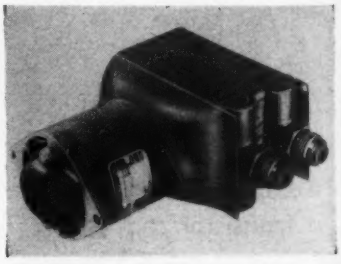
other types of accelerometers. Model 4310 is portable and can be operated from a simple battery power supply providing ± 15 v at 6 ma. Repeatability is 0.01 percent of full-scale and linearity is within 0.05 percent of full-scale. The entire unit weighs 3.2 oz. **Circle 324 on Reader Service Card.**



Temperature Probes used in liquids, gases

ASTRA TECHNICAL INSTRUMENT CORP., 1132 Mission St., South Pasadena, Calif., announces temperature probes for use in liquids and gases. The exposed element, for high response, is capable of response time of 10 millisec in flow and 50 millisec in static condition. Temperature ranges are from −450 F to 2,000 F. This can be extended to 3,500 F on special order. Temperature-resistance curve is linear and positive.

Accuracy of the instrument is dependent only on read-out equipment and resolution of 0.1 F is obtainable. **Circle 325 on Reader Service Card.**



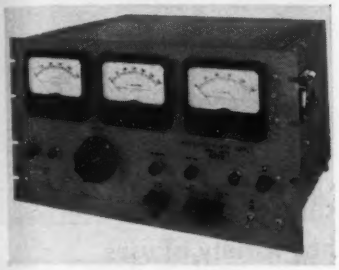
Cooling Unit for electronic equipment

THE GARRETT CORP., 9851 Sepulveda Blvd., Los Angeles 45, Calif., has developed a compact, lightweight package for keeping elec-

tronics "hotboxes" at a cool working temperature.

The unit is composed of a highly efficient circulating fan joined with a heat exchanger, which features great heat transferring capacity per exchanger volume. These factors result in units of relatively small size and weight.

One version weighs only 2.5 lb and measures 7 by 6 by 3 in. However, they are available at custom specifications to meet particular problems over a wide range of cooling requirements. **Circle 326 on Reader Service Card.**



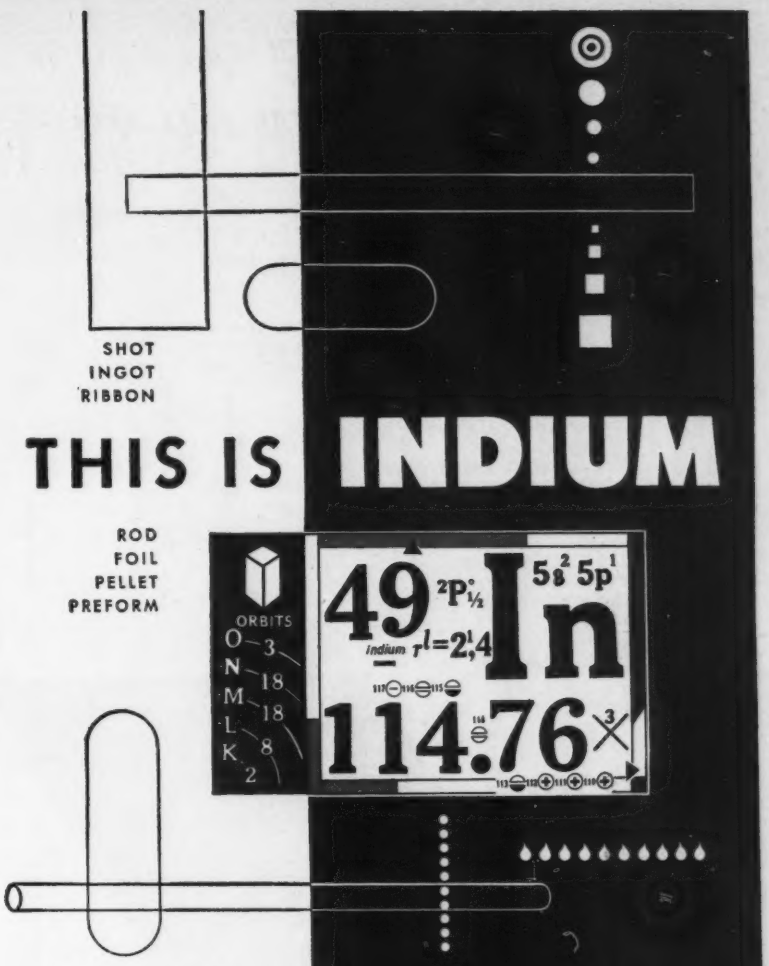
Variable Lab Supply has rugged design

DELTRON INC., P. O. Box 192, Glenside, Pa. Model 6030 supplies voltage from 0-600 v d-c at currents from 0-300 ma d-c at any voltage setting. Advanced circuitry insures rapid transient response with recovery times less than 50μsec. Output will change less than 100 mv for a load change from 0.300 ma d-c or from a line change from 105-125 v. Output ripple is less than 3 mv.

Model 6030 is characterized by its rugged design, featuring all hermetically sealed capacitors, high performance industrial tubes as well as a minimum of 50 percent derating on all components. **Circle 327 on Reader Service Card.**

Portable Oscillator for a-f range

WAYNE KERR LABORATORIES, Tolworth, Surrey, England, has developed a portable, lightweight oscillator which operates in the a-f range. Designed for use in industrial laboratories, the oscillator pro-


SHOT
INGOT
RIBBON
THIS IS INDIUM
ROD
FOIL
PELLET
PREFORM
ORBITS
O 3
N 18
M 18
L 8
K 2
49 2P½ 5s² 5p¹
Indium T^l=2,1,4
In
114.76
• AIDS LUBRICATION
• UNIQUE STABILIZATION
• ALLOYS READILY
QUALITY
at the Indium Corporation of America means purity of metals, and strict adherence to specifications.
SERVICE
means prompt delivery to customers, and technical help in specific uses of Indium.
RESEARCH
means "forward looking" with respect to new products and new techniques.
Metallurgists and engineers in many industries are making startling advances through use of INDIUM in one or more of its various commercial forms:
• Indium metal (specially refined 99.999% pure)
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• Indium wire
• "Indalloy" intermediate solders
• Indium pellets
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• Indium foil and ribbon
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• Other high-purity metals
Why not write us and investigate the possibilities for your product?
WRITE TODAY to Dept. E-458 for new bulletin: "INDALLOY" Intermediate Solders.
THE INDIUM CORPORATION OF AMERICA
1676 LINCOLN AVE. UTICA, NEW YORK
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New PRECISION FREQUENCY

STATIC INVERTER SUPPLY

INPUT 28V D.C. ± 10%

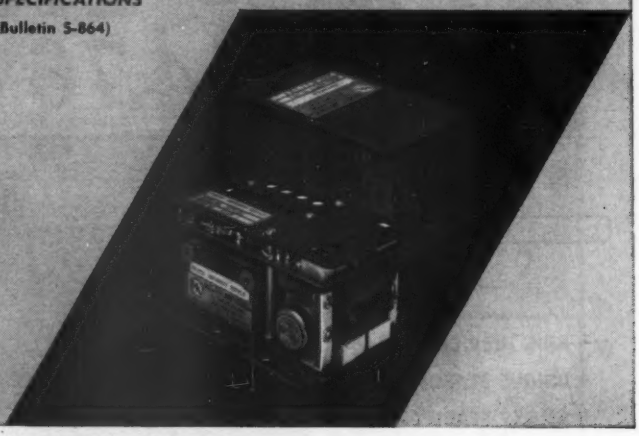
OUTPUT Nom. 115V ± 2% 400 CPS ± 0.01%
1 φ (2- or 3-phase output available)

RATINGS: 30VA 50VA 100VA
Higher ratings available.

APPLICATION:
For gyro wheel supplies and where precise 400 cycle voltages are required in aircraft, radar and missile computers.

FEATURES:
PRECISION OUTPUT FREQUENCY
RUGGED
EXCELLENT WAVEFORM
SIMPLICITY OF CIRCUITRY
FAST STARTING TIME
GOOD VOLTAGE REGULATION throughout an adjustable range
ISOLATED CASE DESIGN
HIGH RELIABILITY
VIBRATION ISOLATED
COMPACT
LIGHTWEIGHT
MILITARY SPECIFICATIONS

(Send for Bulletin S-864)



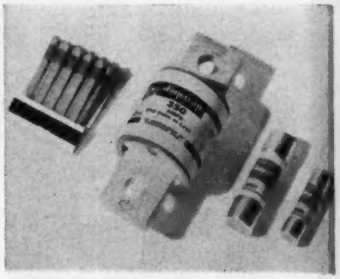
PERFORMANCE SPECIFICATIONS

MODEL NUMBERS				
± .01% CPS	SIS 40311	SIS 40511	SIS 410011
± .05% CPS	SIS 40315	SIS 40515	SIS 410015
INPUT VOLTAGE	28V DC ± 10%		
MAX. OUTPUT POWER	30VA	50VA	100VA
OUTPUT VOLTAGE	115V AC (Adjustable ± 10%)		
OUTPUT FREQUENCY	400 CPS ± .01% 400 CPS ± .05%		
VOLTAGE REGULATION	±1% For Line Variations ±2% For Load Variations		
FREQUENCY DISTORTION	3% Maximum At Full Load		
LOAD POWER FACTOR	+0.5 to −0.5 Maximum		
MILITARY SPECS.	MIL-E-5400A & MIL-E-5272A		
AMBIENT TEMPERATURE	−55°C to +71°C when mounted to heat sink		
VIBRATION	20G 10 to 2000 CPS		
UNIT DIMENSIONS	L5" D 2 7/8" H 2 13/16"	L8" D 2 7/8" H 2 13/16"	L10" D 4 1/2" H 2 13/16"
WEIGHT (Approx.)	2 lbs.	3.5 lbs.	5 lbs.

MA **MAGNETIC AMPLIFIERS INC.**
632 TINTON AVENUE • NEW YORK 55, N.Y. • CYPRESS 2-6610
West Coast Division
136 WASHINGTON ST. • EL SEGUNDO, CAL. • OREGON 8-2665

vides a stable controlled signal within the frequency range of from 10 cps up to 120,000 cps.

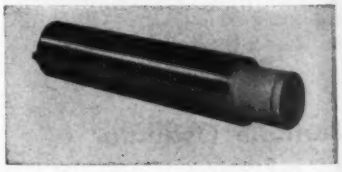
The device has two alternative outputs. One output provides a reference signal covering the range + 10 db to − 70 db in steps of one db. The second output provides a continuously variable control of voltage. A system of dials and controls permit simple and rapid operation. **Circle 328 on Reader Service Card.**



Circuit Protector has variety of uses

THE CHASE-SHAWMUT CO., Merrimac St., Newburyport, Mass. A new circuit protective device, Form 101, has high interrupting capacity and becomes current limiting at about four times its normal current rating. It anticipates and prevents the rise of fault currents to high destructive maximums.

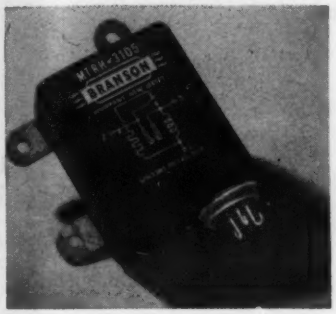
The electronic Amp-trap is available in a wide variety of capacities and sizes for use in 65-130 and 250 v circuits in rectifier, electronic and power applications. It is for protection of germanium and silicon diodes of small sizes as well as oscillograph circuits and very delicate instrumentation. **Circle 329 on Reader Service Card.**



Basic Probe scintillation detector

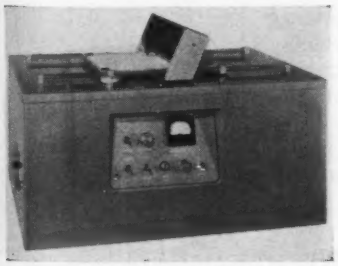
RADIATION COUNTER LABORATORIES, INC., 5121 W. Grove St., Skokie, Ill. A new stainless steel

basic probe scintillation detector is adaptable for use with many crystal and shield configurations. Crystals and shields are easily installed and removed from the probe by means of a threaded locking ring. Basic probe without crystal is available in three models: 11007 without preamplifier; 11008 with preamplifier, and 11009 with cathode follower. Pictured is the basic probe with an exposed crystal, 1¾ in. by 2 in. **Circle 330 on Reader Service Card.**



Time Delay Relay is hermetically sealed

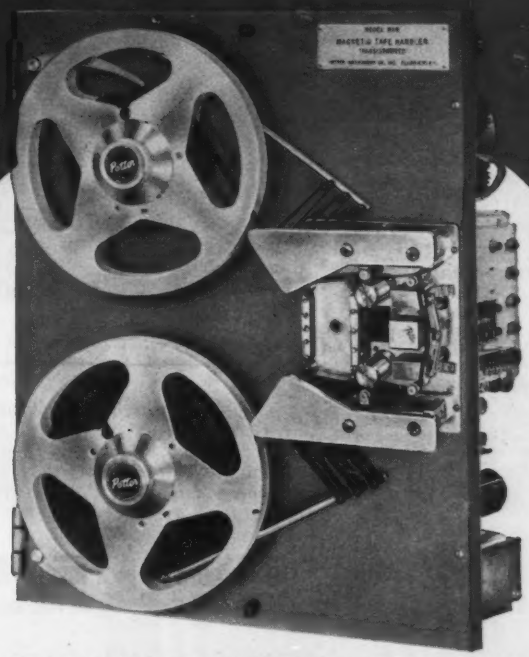
BRANSON CORP., P. O. Box 234, Whippany, N. J., has available the new type MTRH time delay relay. Accurate, repeatable delays of multiple switching are available from 10 milliseconds to 120 seconds. Featuring temperature compensation, and for special applications voltage compensation and extremely high speed recovery, this relay provides a new basis for accurate switching in the small volume, low weight category. **Circle 331 on Reader Service Card.**



Log-Linear Recorder portable unit

RANTEC CORP., P. O. Box 18, Calabasas, Calif. The HSR-1 log-linear recorder is a high speed, accurate,

New Speed...Versatility...Reliability...



TRANSISTORIZED DIGITAL MAGNETIC TAPE HANDLER MODEL 906

Optimum performance in virtually all tape handling applications

The advanced design of the completely transistorized Potter Model 906 Tape Handler provides improved performance in virtually any tape handling application.

Replaceable Capstan Panel permits use as Perforated Tape Reader with a remarkable new brake capable of stopping on the stop character at speeds up to 1000 characters per second. Using a small vacuum loop buffer, Model 906 features:

- Complete front accessibility—single panel construction
- Pinch rollers capable of 100 million start-stop operations
- In-line threading, end of tape sensing and tape break protection
- Speeds up to 150 ips
- As many as 4 speeds forward and reverse
- Capable of continuous cycling at any frequency from 0 to 200 cps without flutter
- Rewind or search at 400 ips
- 3 millisecond starts
- 1.5 millisecond stops
- Tape widths to 1-1/4"
- Up to 47 channels
- All functions remotely controllable

The 906 may be supplied with a transistorized Record-Playback Amplifier featuring a separate module for each channel. Electronic switching from record to playback function is available as an optional feature.

Other Potter products include Transistorized Frequency Time Counters, Magnetic Tape Handlers, Perforated Tape Readers, High Speed Printers, Record-Playback Amplifiers and Record-Playback Heads.

Potter

POTTER INSTRUMENT COMPANY, Inc.

Sunnyside Boulevard, Plainview, New York

OVerbrook 1-3200

PRECISION CAPACITANCE BRIDGE

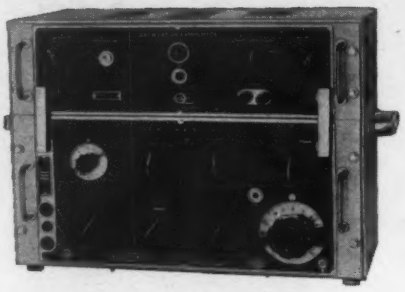
Type
CMB1/OSF1

CAPACITANCE RANGE:
0.001 $\mu\mu$F to 1.111 μF

ACCURACY:
0.1% above 5 $\mu\mu$F
0.0005 $\mu\mu$ below 0.1 $\mu\mu$F

FREQUENCY RANGE:
200 cps to 5 kc/s

POWER FACTOR RANGE:
(at 1000 cps)
0 to 100 • 10^{-3}



Measures directly single capacitances from complex capacitance networks. Shielded cables used without introducing errors. Built-in 1000 cps oscillator and detector. The type CMB1 bridge is unique for all measurements on tubes, cables, transformers, etc.

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BACH-SIMPSON
London/Ontario
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RADIOMETER
72 Emdrupvej, Copenhagen NV, Denmark

CIRCLE 102 READERS SERVICE CARD

OF COURSE—ONE SOURCE

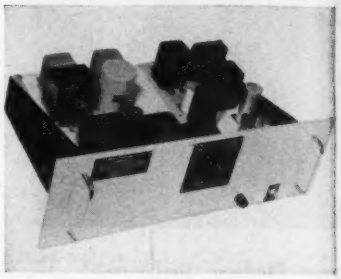
from base laminates
to completed
PRINTED CIRCUITS

Only Norplex offers one-source manufacturing of both base laminates and printed circuits. You get top advantages in service, cost, quality on all circuitry . . . 1 or 2 side, selective soldering, flush for switching applications. Write today, or send print.

Over 5,000,000 Norplex printed circuits in use!

Norplex
Northern Plastics Corp.
Manufacturers and fabricators of industrial laminates for electrical, mechanical application.
Sales offices in principal cities.
2nd and Market Streets, La Crosse 1, Wis.

portable instrument which plots the logarithm of voltage input level as the ordinate and the angular position of a selsyn as the abscissa. Designed primarily to record antenna radiation patterns, the instrument is also useful for other applications. When used with a square-law detector, the recorder has a dynamic range of 40 db with an accuracy of ± 0.1 db. This corresponds to an 80 db voltage range. The instrument has a writing speed of 30 ips, and records in ink on standard 8½ in. by 11 in. reproducible paper. **Circle 332 on Reader Service Card.**



Computer rate-of-change type

Magnetic Instruments Co., 546 Commerce St., Thornwood, N. Y. Model 0557-1 computer is used to measure the rate of change of d-c signals. Of particular interest is the computer's ability to accurately measure slowly varying, low level voltage changes—from 10 to 5,000 μv per sec, superimposed upon static voltages from 0 to 100 mv.

The computer readout is a d-c voltage proportional to the rate of change measured and is suitable for operating any standard recording potentiometer. A selector knob permits a choice of six full scale output ranges, from 100 to 5,000 μv per sec. Faster rates are also possible. **Circle 333 on Reader Service Card.**

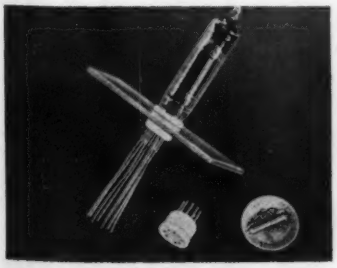
Bondable Wire samples available

American Super-Temperature Wires, Inc., Winooski, Vt., announces Teflon insulated wires and cables with the surface of the insulation treated so that it can be

bonded to various impregnants. The company can supply magnet wire, lead wire, and cable jackets treated in this manner. Individual wires inside the cables can also be provided with a bondable surface. Samples and further information are available. **Circle 334 on Reader Service Card.**

Pot Pressure Pickup for missile application

CONSOLIDATED ELECTRODYNAMICS CORP., 300 N. Sierra Madre Villa, Pasadena, Calif., has announced a small, lightweight potentiometer pressure pickup, featuring minimum response to vibration, and thus specially suited for in-flight missile application. Type 4-380 pressure pickup is designed for absolute and differential pressure measurements of noncorrosive fluids in ranges up to 100 psi. An inherently high level d-c output eliminates the need for signal amplifying equipment. Measured pressure goes directly to a force-summing pressure capsule and remains outside the potentiometer system. Operating temperature range is −65 F to +200 F. **Circle 335 on Reader Service Card.**



Tiny Tube Sockets compression-mounted

FLUOROCARBON PRODUCTS, INC., division of U.S. Gasket Co., Camden, N. J., is offering a new

BALLANTINE

SENSITIVE

WIDE BAND

ELECTRONIC VOLTMETER

measures 1 millivolt to 1000 volts from 15 cycles to 6 megacycles

Accuracy **3% to 3 mc; 5% above**
Input impedance **7.5 mmfds shunted by 11 megs**

When used without probe, sensitivity is increased to 100 MICROVOLTS but impedance is reduced to 25 mmfds and 1 megohm

MODEL 314
Price $285

- Same accuracy at *ALL* points on a logarithmic voltage scale and a uniform DB scale.
- Only *ONE* voltage scale to read with decade range switching.
- No "turnover" discrepancy on unsymmetrical waves.
- Easy-to-use probe with self-holding connector tip and unique supporting clamp.
- Low impedance ground return provided by supporting clamp.
- Stabilized by generous use of negative feedback.
- Can be used as 60 DB high fidelity video pre-amplifier.

All Ballantine instruments are **SENSITIVE - ACCURATE - DEPENDABLE**

Write for catalog for complete information.

BALLANTINE LABORATORIES, INC.

100 FANNY ROAD, BOONTON, NEW JERSEY

marion
advancement in instrument design

INDUCTION SOLDERING UNIT

Model PM 1

FOR SMALL PARTS AND ASSEMBLIES

Simplifies, improves and speeds up component production. Provides local heat to otherwise inaccessible spots. Safe and simple. Max. power input 775 watts, 100 watts standby; 115 volts, 60 cycles. 15¾" x 21½" x 15". 150 lbs. Bulletin on request. Marion Electrical Instrument Co., Manchester, N. H., U. S. A.

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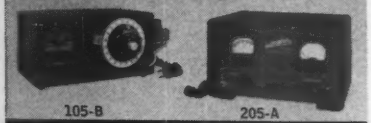
marion meters
"WHERE ELECTRONICS MEETS THE EYE"

CIRCLE 105 READERS SERVICE CARD

I'm Building a College Fund for My Kids with the
EXTRA MONEY
I'm earning in Mobile-Radio Maintenance!

I couldn't set aside from my engineer's salary enough money to send the kids through college. So when I learned of the boom in mobile-radio I decided to start my own part-time business. Now my income from mobile-radio maintenance goes into a "college bank account."

This can be your story, too. Send coupon for your free copy of "HOW TO MAKE MONEY IN MOBILE-RADIO MAINTENANCE." Published by Lampkin Laboratories, Inc., manufacturers of the 105-B Micrometer Frequency Meter and 205-A FM Modulation Meter.



105-B 205-A

LAMPKIN LABORATORIES, INC.
Instruments Div., Bradenton, Fla.

At no obligation to me please send "HOW TO MAKE MONEY IN MOBILE-RADIO MAINTENANCE."

Name_____

Address_____

City_____ State_____

CIRCLE 106 READERS SERVICE CARD

Chemelec Teflon subminiature tube socket which has high reliability under extreme shock, vibration, high temperature; low-loss insulating qualities, zero moisture absorption.

In addition, its compression-mounted design requires no mounting hardware and saves space and assembly time. This socket is simply pressed into a single chassis hole, slightly smaller than the Teflon body of the socket. The plastic "memory" of the Teflon causes it to expand again to its original diameter, after compression, to lock the socket securely and permanently in place.

It is versatile, adaptable to printed circuitry, and also can be used as chassis mounted tube lead insulator. **Circle 336 on Reader Service Card.**

D-C Amplifier chopper stabilized

ALLEGANY INSTRUMENT CO., INC., 1091 Wills Mountain, Cumberland, Md. Model 512 chopper stabilized d-c amplifier features low drift of ± 2 μv; low noise level of 5 μv. The amplifier unit is coupled to the one-channel power unit, both having their own chassis for economy and convenience in multichannel operation. This configuration allows a single power supply to be used with six channels of amplification in a single 19-in. rack. Input impedance is 100,000 ohms; linearity, better than 0.1 percent; frequency response, d-c to 10 kc; gain 0-1,000 in ten steps;

MODERN COIL EQUIPMENT
Plus
MODERN COIL HANDLING
Insure perfection in
all DANO COILS

- Encapsulated coils . . . in either polyester or epoxy resins.
- Coils for high temperature applications.
- Bobbins coils.
- Paper interleave coils.
- Cotton interweave coils.
- Form wound coils.

ALSO TRANSFORMERS MADE TO ORDER

THE DANO ELECTRIC CO.
MAIN ST., WINSTED, CONN.

CIRCLE 163 READERS SERVICE CARD

CABLE CLIPS
★
of all Nylon
for severe conditions
★
of Ethyl Cellulose
for maximum economy

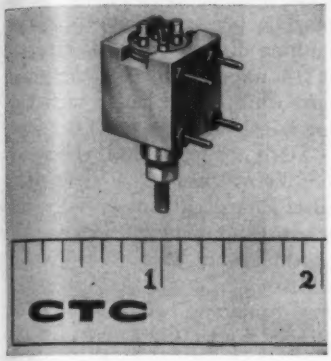
WECKESSER

molded Black Nylon SCREWS and NUTS
★ Acid resistant
★ Need no insulation
★ Can't rust
★ Can't corrode

WECKESSER COMPANY
5701 Northwest Highway • Chicago 30, Ill.

CIRCLE 107 READERS SERVICE CARD

size with single-channel power unit, 6½ in. high, 2⅞ in. wide, 19 in. deep. **Circle 337 on Reader Service Card.**



Shielded Coil Form for i-f strip work

CAMBRIDGE THERMIONIC CORP., 445 Concord Ave., Cambridge 38, Mass., is producing a new horizontally mounted r-f shielded coil form.

This completely shielded coil form assembly, using internal powdered iron components of unique design, is ideal for i-f strip work where ease of tuning, compactness, and dependability under rigorous service conditions are required. The assembly can be chassis mounted by means of four No. 2-56 screws, or four pin mounted to printed wiring. Required mounting holes are on 0.400 in. by 0.300 in. centers. The mounted assembly is ½ in. wide by ½ in. high. A positive compression-type tuning core lock is provided. **Circle 338 on Reader Service Card.**

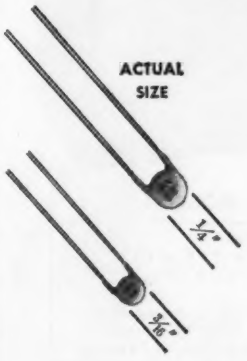
Test-Point Jack for shallow assemblies

SEALECTRO CORP., 610 Fayette Ave., Mamaroneck, N. Y. For assemblies where depth is a vital

Ultra-Miniature Low Cost Capacitors for Transistor Circuits

Centralab.

ULTRA-KAP*



. . . with performance characteristics that equal or exceed much larger or more costly components. Excellent temperature stability: plus or minus 25% from 10° to 85° C. Extremely low power factor. Working voltage, 3 VDC. GMV tolerances. Maximum thickness, 0.156".

TYPICAL SIZES

.10 mfd	3/16" diameter
.22 mfd	¼" diameter
.47 mfd	3/8" diameter
1.0 mfd	5/16" diameter
2.2 mfd	¾" diameter

For detailed information write for Engineering Bulletin EP-87 or contact your local Centralab sales representative.

Centralab *Trade Mark D-5812

A DIVISION OF GLOBE-UNION, INC.
914D E. KEEFE AVE. • MILWAUKEE 1, WIS.
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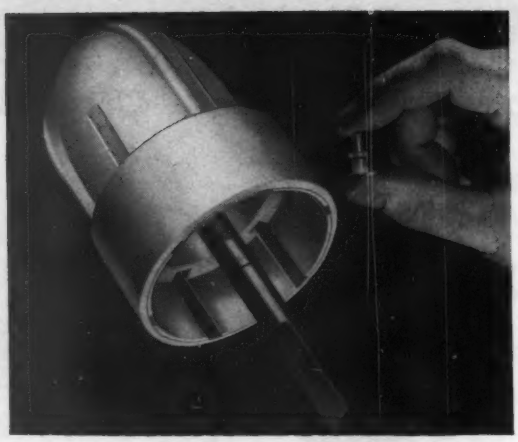
VARIABLE RESISTORS • PACKAGED ELECTRONIC CIRCUITS • ELECTRONIC SWITCHES
CERAMIC CAPACITORS • ENGINEERED CERAMICS • SEMI-CONDUCTOR PRODUCTS

Pilot Runs at
LOW COST
to your
specifications



market trials are important

If you're planning a pilot run before starting full production, let us do it for you at *very low cost* . . . regardless of product size, shape or quantity. Special facilities also available to work out your production problems. Write us today! All inquiries receive our prompt and interested attention.

Custom molders of the unusual

STANDARD PLASTICS CO., Inc.

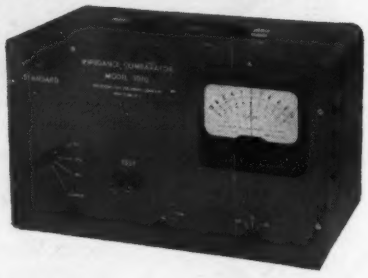
62 WATER ST., ATTLEBORO, MASS., Tel. AT. 1-1940
N. Y. OFFICE: 303 FIFTH AVE., Tel. MU. 9-1910

CIRCLE 109 READERS SERVICE CARD

IMPEDANCE COMPARATORS

PRECISE, RELIABLE AND RAPID COMPARISON OF COMPONENTS

- Tests Resistors, Condensers, Inductors
- Percentage Deviation From Standard Read On Large Meter
- Rapid Response — No Buttons To Push
- High Accuracy And Stability
- Self Calibrating — Requires No Recalibration When Changing Ranges



SPECIFICATIONS	MODEL 60	MODEL 1010
BRIDGE SUPPLY	6 Volts	2 Volts
FREQUENCY	60 CPS	Either 1 KC or 10 KC
FULL SCALE RANGES	±1%, ±5%, ±10, ±20%	±5%, ±10%, ±20%
IMPEDANCE LIMITS:		
Resistance	5 ohms to 5 megohms	5 ohms to 5 megohms
Capacitance	500 mmfd. to 500 mfd.	50 mmfd. to 10 mfd.
Inductance	15 millihy. to 10,000 hy.	100 microhy. to 100 hy.
PRICE	$179.00	$299.00

OTHER MODELS AVAILABLE

MODEL	BRIDGE VOLTS	FULL SCALE RANGES
1000	8V-1000 CPS	±1, 5, 10%
1025	2V-1 KC, 25 KC	±5, 10, 20%
400	8V-400 CPS	±1, 10, 20%
60-S	.2V-60 CPS	±1, 2, 10, 20%

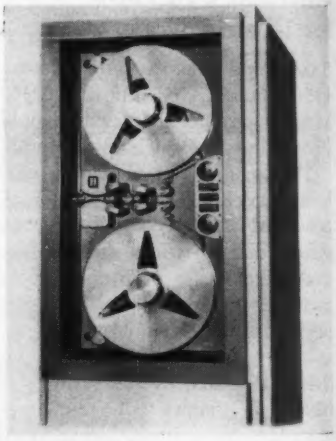
Representatives in Principal Cities

INDUSTRIAL TEST EQUIPMENT CO.
55 EAST 11th STREET • NEW YORK 3, N. Y.

factor, two shortened versions of the SKT-10 test-point jack have been made available.

Types SKT-2BC and SKT-5BC have identical dimensions but take 0.080 in. and 0.090 in. diameter pins or plugs, respectively. The bushing diameter is 0.185 in. and 0.218 in. diameter for the front face, while overall length including lug is 7/16 in.

Machined contact members of beryllium-copper gold flash over silver provide a firm grip for the inserted pin or plug. Teflon body provides ideal insulation for the widest range of climatic and operating conditions. **Circle 339 on Reader Service Card.**



Tape Transports for telemetry

DAVIES LABORATORIES Division of Minneapolis-Honeywell Regulator Co., 10721 Hanna St., Beltsville, Md., has introduced a new precision tape transport for telemetry applications and other analog data acquisition systems. With the system, which exceeds IRIG requirements, data can be recorded separately or in combination by direct-recording frequency modulation or pulse-width modulation.

The transport is equipped to handle up to 14-in. reels as standard, accommodating tape widths of ¼ in. to 2 in. and capable of being changed in the field. Six tape speeds—60, 30, 15, 7½, 3¾ and 1⅞ ips—are available instantaneously by selective switching.

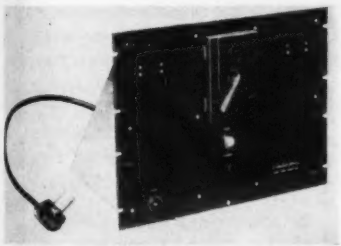
Other features include a search

and control capstan at 120 ips, that permits selection of descriptive data at any point on the tape; precision servo-type tape tension control, and sensing arms that automatically stop the tape before the end of the reel without use of special stops. **Circle 340 on Reader Service Card.**

Ultrasonic Cleaner for industry, lab use

HERMES SONIC, 13-19 University Place, New York, N. Y., has announced a new one-gallon portable ultrasonic cleaning unit for industrial and laboratory use. It is designed for hard-to-clean objects and intricately assembled parts. Powerful sound waves, beyond the range of human hearing, are propelled into the cleaning solution to create a powerful scrubbing action even on minute, hard-to-reach areas.

In addition to cleaning, the unit is highly effective for degreasing, decontamination, removal of excess flux, mixing, and emulsifying. **Circle 341 on Reader Service Card.**



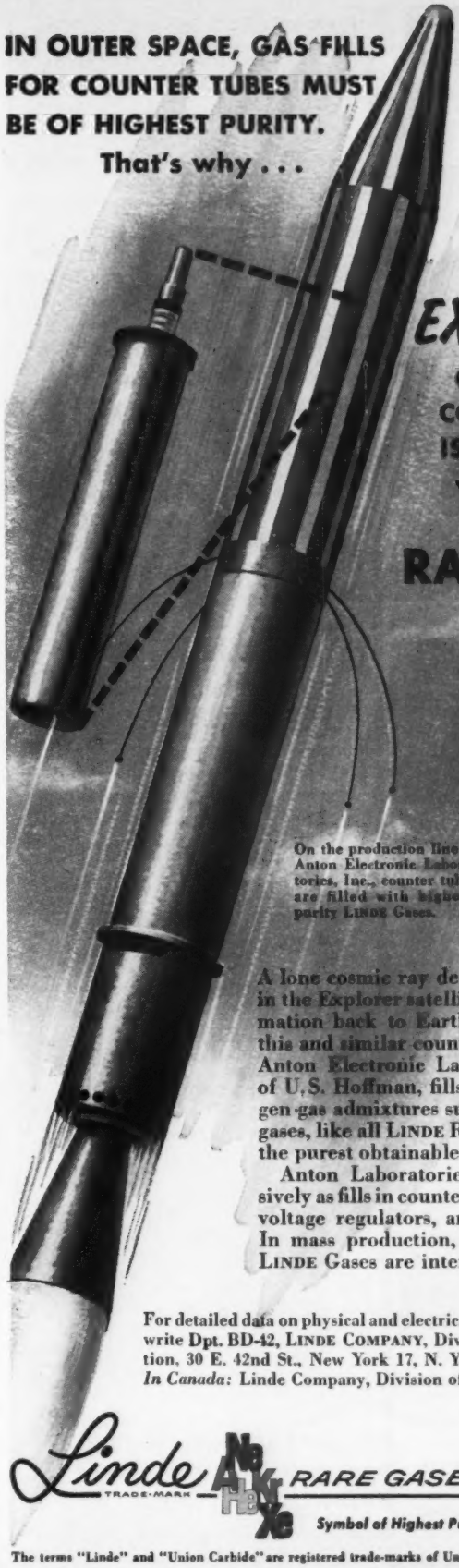
Magnetizer compact, heavy duty

ELECTRO-VOICE, INC., Buchanan, Mich. Model 6800 magnetizer offers trouble-free, longlife operation. The unit charges any permanent magnet within the size limitations of the coil dimensions.

Magnets to be charged may be

IN OUTER SPACE, GAS FILLS FOR COUNTER TUBES MUST BE OF HIGHEST PURITY.

That's why . . .



EXPLORER'S COSMIC RAY COUNTER TUBE IS FILLED WITH 'LINDE' RARE GASES

On the production line at Anton Electronic Laboratories, Inc., counter tubes are filled with highest-purity LINDE Gases.

A lone cosmic ray detection and measuring tube in the Explorer satellite steadily sends vital information back to Earth. To be absolutely certain this and similar counter tubes perform perfectly, Anton Electronic Laboratories, Inc., subsidiary of U. S. Hoffman, fills them with neon and halogen-gas admixtures supplied by LINDE. For these gases, like all LINDE Rare Gases and Mixtures, are the purest obtainable on Earth.

Anton Laboratories uses LINDE Gases exclusively as fills in counter tubes, surgical probe tubes, voltage regulators, and other electronic devices. In mass production, identical tubes filled with LINDE Gases are interchangeable.

For detailed data on physical and electrical properties of LINDE Rare Gases, write Dpt. BD-42, LINDE COMPANY, Division of Union Carbide Corporation, 30 E. 42nd St., New York 17, N. Y. Offices in other principal cities. *In Canada:* Linde Company, Division of Union Carbide Canada Limited.

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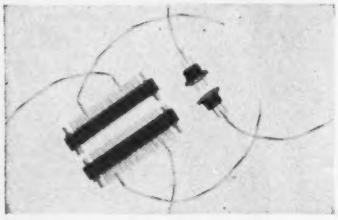
in their assemblies, provided certain considerations are met. Two sizes of coil structures are standard accessory items. Special custom made coils can also be designed for specific applications.

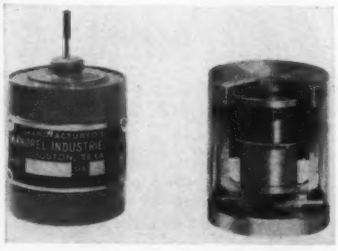
To eliminate the necessity for a bulky, short-lived capacitor bank, push-pull ignitrons are used across a 220-v line. They are triggered by a pair of mercury vapor rectifiers, which in turn are controlled by Agastat time delay relays. **Circle 342 on Reader Service Card.**



Tiny Connectors surpass MIL-C-8384

GORN ELECTRONICS DIV., Gorn Electric Co., Inc., 845 Main St., Stamford, Conn., offers from stock a complete line of miniature rectangular and hexagonal connectors, terminated for "Amp 37" taper pin receptacles.

The GHT hexagonal series offers sizes 4, 5, 7, and 9 contact arrangements and the GMT series offers 7 through 50 contact arrangements. These connectors can be supplied in a variety of molded materials, and equipped with polarizing guides, Thread-Locs, Snappy-Jectors, and hood cable enclosures with vibration clamps. **Circle 343 on Reader Service Card.**



Linear Force Motor a moving coil device

MANDREL INDUSTRIES, INC., P. O. Box 13243, Houston 19, Texas. The Dynastroke linear force motor

If the cost of metal stampings and wire forms figures in your profit picture, let us give you a quotation on your current components. Send us a sample or blueprint . . . and discover how big savings in time and production costs, big gains in precision and uniformity are possible on small components, when Art Wire tackles the job!

Our engineering staff, our production experience, and our modern high speed equipment are always at your disposal. If you wish to learn more about what a wide and versatile range of shapes and parts we can produce for you—at lower cost than you'd guess—just write for our illustrated folder.

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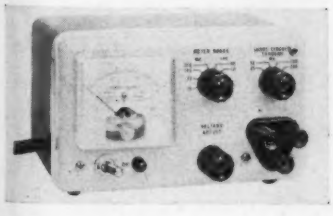
is available with strokes to 0.10 in. and force outputs to 2 lb. Standard coil resistances are from 200 to 4,000 ohms with resonant frequencies from 10 to 100 cps. Extremely rugged construction and use of spring suspensions to eliminate friction assure permanent accuracies of better than 0.1 percent. Less than 2 in. long and $1\frac{3}{8}$ in. in diameter, the unit can be supplied completely sealed and will operate over wide temperature ranges. **Circle 344 on Reader Service Card.**

Amplifier for galvanometers

ALLEGANY INSTRUMENT CO., INC., 1091 Wills Mountain, Cumberland, Md. The Alinco System D is a 4-channel, trouble-free galvanometer amplifier package which includes power supply. It is well suited for use with wire strain gages, transducers and thermocouples, and will drive even low-sensitivity, h-f galvanometers, providing excellent linearity over a wide range of input voltages.

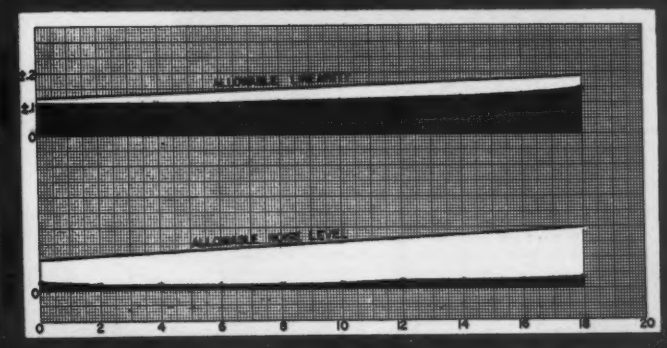
Features include: balanced input, high output (±60 ma), phase sensitivity, high stability, low noise level, overload indicator and protector, and no operational delay when overloaded. **Circle 345 on Reader Service Card.**



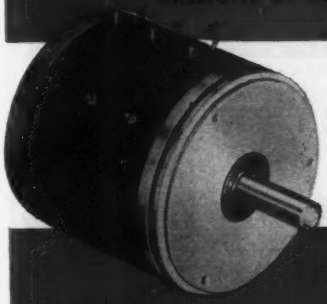
Power Supply transistorized

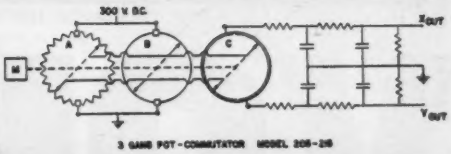
HEWLETT-PACKARD CO., 275 Page Mill Road, Palo Alto, Calif. The 721A is a completely transistorized,

With CARBON FILM POTS you get life of 18,000,000 revolutions



MILLIONS OF REVOLUTIONS AT 625 R.P.M.





3 GANG POT-COMMUTATOR MODEL 208-2B

PROBLEM

airborne radar antenna mounted on board to rapid fire guns rotates continuously at 625 rpm. Pot pick-off on mount indicates antenna position on a scope. Effective linearity of pot ±.12%. Ambients −73°C to 71°C, sea level to 60,000 feet, humidity, shock, vibration per MIL-E-5272A. Pot must operate to specs for 500 hours at 625 rpm, equivalent to more than 18,000,000 revolutions.

SOLUTION

Precision carbon film potentiometer ganged with C.I.C. commutator cups meet all performance requirements, with a life well beyond 18,000,000 revolutions at 625 rpm on production-line units.

The smooth surface of the carbon film combined with its natural lubricative properties insures long life at high speed. Wipers are not required to follow the contours of wire windings, therefore, with very low brush pressures which enhance pot life, no wiper bounce occurs at high speeds.

The continuity of the resistance element does not depend upon a single hair-like wire. Failure of the potentiometer therefore does not occur suddenly, but any deterioration of performance is gradual. This fail-safe characteristic enhances reliability, and insures against catastrophic system failure at critical times.

Your critical pot requirements can readily be met with C.I.C. Precision Carbon Film Pots and Commutators. We welcome your inquiries.

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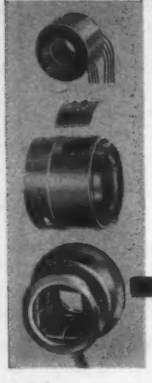

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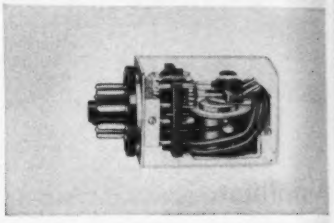
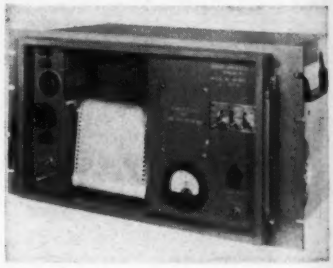


Relay in plastic enclosure

GUARDIAN ELECTRIC MFG. CO., 1621 West Walnut St., Chicago 12, Ill. Series 1210 relay is encased in a dust-tight transparent plastic enclosure that withstands heavy impacts. The unit is unaffected by weather and resists temperatures up to + 200 F. Contact rating is: 8 amperes, 155 v, 60 cps, noninductive. The relay is available in any a-c voltage 6 to 230 and in any d-c voltage 6 to 110. Corrosion proof and sturdy, it should give long-lasting, efficient service. **Circle 347 on Reader Service Card.**



Level Recorder for marine use

SOUND APPARATUS CO., Stirling, N. J. The marine level recorder model SL-4M has been specially

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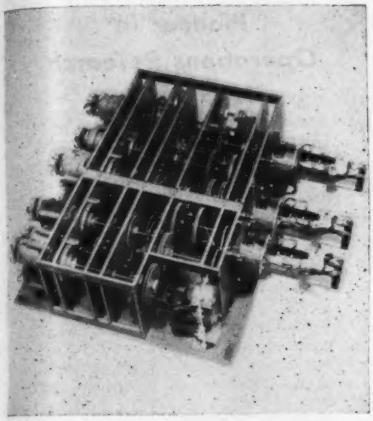

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designed for operation in humid and rugged conditions which often exist in tropical climates, or aboard ships, or in the field. It is a compact, rack-mounted recorder for frequency response, sound, noise and vibration measurements, featuring: complete moisture-proof, anodyzed metal enclosure; Plexiglass hinged door on front panel, protecting the entire recording mechanism; chart take-up device; and lifetime cooling fan. **Circle 348 on Reader Service Card.**

Slip Rings for rugged use

SERVONIC INSTRUMENTS, INC., 640 Terminal Way, Costa Mesa, Calif. Model R series slip rings are custom constructed to specific requirements. Solid coin silver conductors and pyrex glass inserts for circuit interruption are embedded in a matrix of non-nutrient epoxy plastic reinforced with fiber glass.

The typical model shown was designed for airborne operation and contains several channels, some of which are separated into segments for phase shifting. Conductors are rated for continuous operation at 20 ma, 300 v with low noise level. Transient voltages to 1,500 v may be tolerated and insulation and mounting structure is not less than 5 megohms under specified environments. **Circle 349 on Reader Service Card.**

Magnet Wire for high temperature

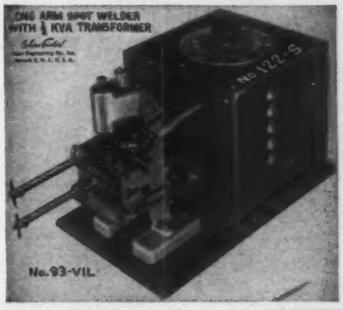
SECON METALS CORP., 7 Intervale St., White Plains, N. Y., has developed two new types of magnet

EISLER VERTICAL SPOT WELDERS

MADE IN SIZES ½—1—2—3—5 KVA

WITH OR WITHOUT TRANSFORMER OR TIMER

Sent to Any Radio Tube Manufacturer in U.S.A. on a 30 Day Free Trial Basis.



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MODEL USA-3

- RELIABILITY: No electrolytic capacitors or glow tubes. Designed to prevent self-destruction even when the output is short circuited.
- DRIFT, NOISE, OFFSET: Under 100 microvolts.
- LARGE OUTPUT VOLTAGE: 230 volts peak-to-peak.
- WIDE FREQUENCY RANGE: DC to 100kc (attenuation less than 3db) when connected as a gain-of-ten amplifier.
- COMPACT SIZE: 7 x 2½ printed circuit board, mounts by any convenient method.

One of several types of modular packaging available at slight extra cost.

For full information, write George A. Philbrick Researches, Inc., Dept. EL 1. Ask for Bulletin USA-3.

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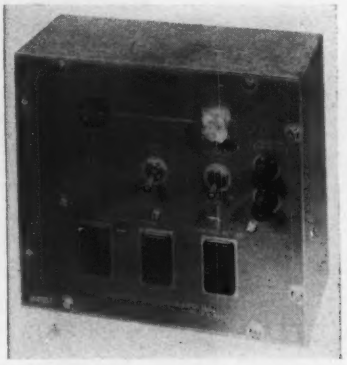
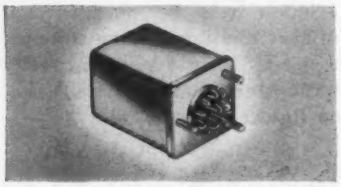
wire for high temperature relay use. One of these has a specially bonded refractory insulation which is rated for continuous use at 700 F and for intermittent use up to 800 F. The other wire has a ceramic insulation which is rated for continuous use at 1,000 F. Both of these insulations are normally supplied on copper wire. However, they may be supplied on other metals or alloys which have better high-temperature characteristics. **Circle 350 on Reader Service Card.**



Control Box has new electronic circuit

LABLINE, INC., 3070-82 W. Grand Ave., Chicago 22, Ill., has a new electronic control box featuring a new circuit with improved operating characteristics.

The control box has 3 plug-ins for controlling heaters, stirrers, alarm circuit, liquid level controls, constant temperature bath, and the like. Duplex terminals are connected to control circuit, such as, liquid level controller, sensitive mercury-in-glass regulators. Ideal for a mercury-in-glass regulator, the control circuit pulls only 5 μa. **Circle 351 on Reader Service Card.**



Relay hermetically sealed

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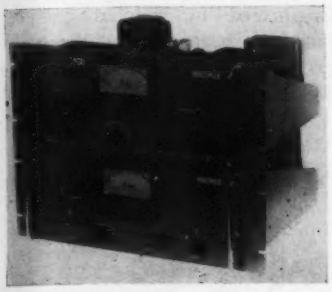
12, Ill. Series 3205 relay is a 10-ampere hermetically sealed unit designed to meet and exceed test requirements of specification MIL-R-6106-B-Class B.

The 4 pdt relay utilizes the same size envelope container as the AN3304 (3 ampere relay) and is essentially the same overall weight. **Circle 352 on Reader Service Card.**



SSB System uses multiplex method

KAHN RESEARCH LABORATORIES, INC., 22 Pine St., Freeport, N. Y. announces the Voiceplex model VP-55-1A. The system, utilizing a novel frequency division multiplex method, permits transmission of two voice channels in the same frequency spectrum normally occupied by one.

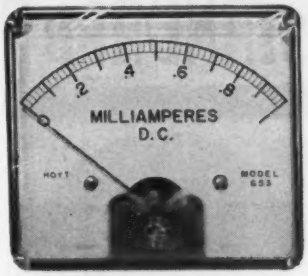
Voiceplex may be used on radio circuits, land-line telephones, vhf links, scatter relays, or any other type of facility requiring the transmission of voice mesages. Spectrum requirements are only 300 to 3,000 cps.

Complete system consists of a transmitter and receiver, each fitting into a 7-in. by 19-in. rack space. **Circle 353 on Reader Service Card.**

Shift Registers miniaturized

EPSCO COMPONENTS, 108 Cummington St., Boston, Mass., intro-

SPECIFY Hoyt METERS



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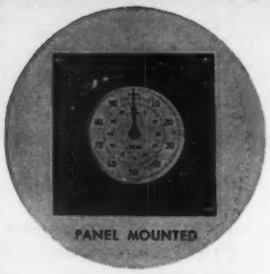
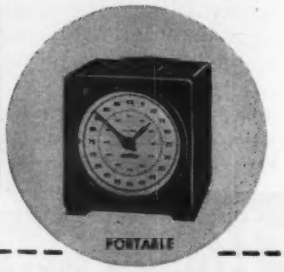
Model	Scale Divisions	Totalizes	Accuracy
S-100	1/5 sec.	6000 sec.	±.1 sec.
S-60	1/5 sec.	60 min.	±.1 sec.
SM-60	1/100 min.	60 min.	±.002 min.
S-10	1/10 sec.	1000 sec.	±.02 sec.
S-6	1/1000 min.	10 min.	±.0002 min.
S-1	1/100 sec.	60 sec.	±.01 sec.
MST	1/1000 sec.	.360 sec.	±.001 sec.
MST-500	1/1000 sec.	30 sec.	±.002 sec.





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Bliley CRYSTALS

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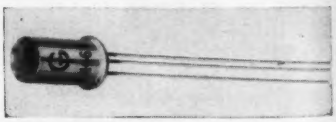
duces a new line of miniaturized shift registers known as Minibits. With operating rates up to 500 kc and above . . . fully encapsulated, they offer substantial savings in weight and space. Actual size is ½ in. cube, totaling ⅛ cu. in. per binary digit.

Other significant features of Minibits are their low power consumption and their high reliability. Engineered for printed circuits, they have been designed especially for severe service conditions. **Circle 354 on Reader Service Card.**

P-C Vtvm with tilting meter

PRECISE DEVELOPMENT CORP., 2 Neil Court, Oceanside, N. Y. Model 904 printed-circuit, voltage-regulated vacuum-tube voltmeter, permits the user to tilt the meter movement to eye level from any angle for more accurate readings, and has a magic lead switch that automatically shorts or opens test leads for zero and infinite ohms adjust.

Meter reads peak-to-peak and rms voltages. Frequency range is up to 250 mc when used with the 912 probe, and voltage range goes up to 30,000 v with the 999 h-v probe. **Circle 355 on Reader Service Card.**



Phototransistor small *pnp* type

GENERAL TRANSISTOR CORP., 91-27 138th Place, Jamaica 36, N. Y., has available a new style *pnp* photo-

Reliable Electrical Connections

by R. George Roesch

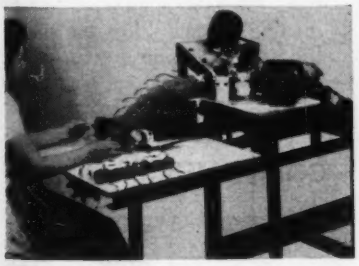
Eliminate Manual Operations for Uniformity

The efficiency of many manual wire-processing operations may now appear to be perfect for the specific jobs for which they are used. The actual efficiency, however, is limited by the manual operations. It is impossible for anyone to do something time after time, exactly the same way. Honest human effort can result in some errors.

Mechanized Wire Processing

One logical way of attaining practical quality control of wire processing—has proved to be mechanized Wire Processing Equipment developed for the specific job.

Assuming uniformity of product up to the Wire Processing Equipment, such mechanical processing can result in uniform high quality every time.



A typical example is this mechanized wire cutter and stripper designed for shunt coils wound with AWG No. 30 Formvar-insulated wire. Except for hand loading, the operation is completely automatic, at the rate of 1,620 coils per hour with one operator.

If you have a production wire-processing job, we would like to discuss it with you.

THE ERASER CO., INC.
1068 S. Clinton St., Syracuse 4, N. Y.

REPRESENTATIVES:

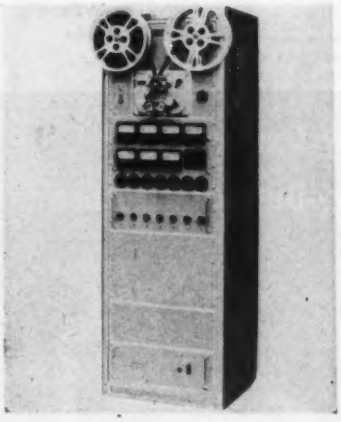
There are still a few choice territories open, offering unusual opportunities for service and profit. Write R. George Roesch.

CIRCLE 123 READERS SERVICE CARD

transistor, type 2N469. It is a highly improved version of the GT type 2N318 phototransistor, being smaller, and having greater optical sensitivity. The new device has a wide variety of industrial and military applications where light is utilized to activate electronic equipment. It is especially important in punched card and tape readouts in computer systems.

The primary advantages of the 2N469 phototransistor over conventional photo devices are small size, low power consumption, head-on construction, good light sensitivity, high gain and low leakage current. The 2N469 is also extremely resistant to shock and vibration and is capable of reliable, long-lasting performance under the most rugged conditions.

Other applications include smoke density control, automatic machining operations, automobile headlight dimmers, and burglar alarm system. **Circle 356 on Reader Service Card.**



Recorder/Reproducer multichannel unit

Magnasync Mfg. Co., Ltd., 5546 Satsuma Ave., North Hollywood, Calif., announces new multichannel data recording and reproducing equipment. The system employs perforated 35 mm magnetic film as recording media. Film is driven by a 32 tooth precision sprocket and synchronous drive motor to insure positive timing accuracy required for rocket engine testing and missile tracking. Audio components are plug-in assemblies. **Circle 357 on Reader Service Card.**

the multi-channel heart of any automation system...
BEATTIE-COLEMAN'S
LPR-6
PROGRAMER
Twelve functions controlled through integral relays
Six channels operated by punched Mylar tape
This LPR-6 Programer is the inexpensive laboratory version of the famous Beattie-Coleman MPR-13 missile Programer. Immediate delivery. Let us show you how the LPR-6 can help solve your programming problems.
Up to 30 minutes of repeated program
Over-all timing accuracy of .05%
BEATTIE-COLEMAN inc.

1000 N. Olive St., Anaheim, California

CIRCLE 124 READERS SERVICE CARD

THE BEST IN STATION RECEIVERS

Aerocom's Model 77 single-channel H.F. crystal-controlled receiver was designed and built to meet your needs.

A high-performance, rack-mounted, rugged receiver, designed for reception of A1, F1 or A3 signals. Frequency range is from 2 MCS to 24 MCS, using permanently mounted R.F. coils which are selected by rotary switch. *(No plug-in coils).* Can be operated continuously in any climate from hot and humid to very cold. *Crystal* band-pass filter used in I.F. amplifier. 6 KC width normally supplied for A3 and 1.8 KC width normally supplied for FSK.

Two Model 77 receivers can be used in a space-diversity system by using Aerocom's Model DRC diversity combining unit.

Power supply 115 Volts or 230 Volts 40/60 Cycles single phase. All controls on front panel, each with switch to permit remote operation.

Removable front cover permits access to all parts for checking without removing receiver from rack.

Miniature tubes extend from rear, providing maximum cooling.

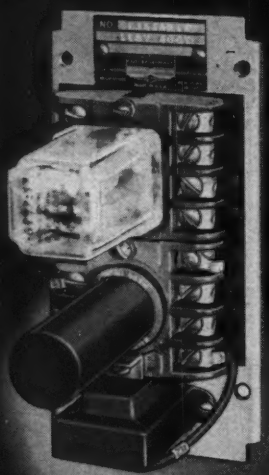
AER-O-COM

3090 S.W. 37th Avenue
Miami 33, Florida

CIRCLE 135 READERS SERVICE CARD

NEW Transistorized Relay Combines Fine-Sensitivity with Heavy-Duty Construction

Cutler-Hammer has developed a heavy-duty transistorized A-c relay which will respond to either an A-c or D-c signal between .002 and .02 amperes. The heart of this compact relay is the plug-in type signal-amplifying module which contains all the electronic parts. This tough module is practically indestructible, and the plug-in design simplifies maintenance . . . cuts downtime to a minimum. The Bulletin 13535 transistorized relay requires no warm up time and it is exceptionally quick in operation. Relay is rated at 10 amperes, 110 volts and the price is unusually low. Cutler-Hammer also offers conductive liquid level probes, and photo-cell units for use with the transistorized relay. For further information, write today for Bulletin 13535.



CUTLER-HAMMER
MOTOR CONTROL
C-H

CUTLER-HAMMER Inc.,
1230 St. Paul Ave., Milwaukee 1, Wis.

Literature of

MATERIALS

Alloys. The Carpenter Steel Co., 370 West Bern St., Reading, Pa. The engineering properties and fabrication characteristics of a complete range of special alloys for electronic, magnetic and electrical applications are detailed in a new 64-page book recently issued. A useful glossary of terms is included. **Circle 358 on Reader Service Card.**

Ceramic Catalog. Centralab, 900 E. Keefe Ave., Milwaukee 1, Wisc. A 16-page manufacturers' ceramic catalog featuring high alumina bodies in addition to Steatite, Cordierite, and Zirconite ceramics is available. **Circle 359 on Reader Service Card.**

H-F Insulating Materials. Electronic Mechanics, Inc., 101 Clifton Blvd., Clifton, N. J. Bulletin 101 covers all types of Mykroy, a glass-bonded mica, Thermica synthetic powdered mica, and other types of new high-frequency insulating materials for use in electric and electronic devices. **Circle 360 on Reader Service Card.**

COMPONENTS

Electrical Connector. The Pyle-National Co., 1334 N. Kostner Ave., Chicago 51, Ill., has available a new 62-page catalog on their Pyle-Star-Line compact, low-weight, environment-resistant connectors. Two major series of connectors are fully described with detailed specifications and selection data. **Circle 361 on Reader Service Card.**

Precision Potentiometers. Analogue Controls, Inc, 39 Roselle St., Mineola, N. Y. Catalog No. P103 contains description, specifications and dimensional drawings of a line of precision potentiometers. **Circle 362 on Reader Service Card.**

Polystyrene Dielectric Capacitors. Aerovox Corp., New Bedford, Mass. A new engineering bulletin

the Week

describes a complete line of polystyrene dielectric capacitors in hermetically-sealed tubular, bathtub and upright rectangular case styles. Complete size, capacitance and voltage charts are included as well as temperature curves. **Circle 363 on Reader Service Card.**

R-F Filters. Microphase Corp., Box 1166, Greenwich, Conn., has released an 8-page catalog on its high-performance r-f filters. It shows representative types and performance characteristics of various high-pass, low-pass, band-pass, diplexing and multiplexing filter networks, and preselectors. **Circle 364 on Reader Service Card.**

Slip Ring Assemblies. Slip Ring Co. of America, 3612 West Jefferson Blvd., Los Angeles 16, Calif., pictures over 50 slip rings, brushes, commutators and drums in their new brochure. The nine methods of manufacturing these units are disclosed along with the different materials and end uses of the product. Each slip ring is described in detail. **Circle 365 on Reader Service Card.**

Solid Tantalum Capacitors. Texas Instruments Inc., P. O. Box 312, Dallas, Texas. The tan-TI-cap solid tantalum capacitors, illustrated and described in new literature now available, provide ratings up to 200 μf at 6 v and 25 μf at 35 v. The units discussed are designed for transistorized equipments, coupling transistor stages, r-c timing circuits and power supplies. Characteristics and test conditions are given in the bulletin. **Circle 366 on Reader Service Card.**

EQUIPMENT

Anechoic Chambers. Industrial Acoustics Co., Inc., 341 Jackson Ave., New York 54, N. Y., has published an 18-page manual on the application and use of anechoic chambers. Use of the chambers in product research and development is shown. Complete specifications for a new line of prefabricated

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— all ways

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Radio Cores, Inc.

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★ the leader in price ★ the leader in engineering
★ the leader in volume ★ the leader in design

Just a few short years ago, Iron Cores cost over 100% more than at the present time. This has been achieved by the creation of our line of ENGINEERED ECONOMY* IRON CORES which enables us to reduce the amount of your minimum inventory through guaranteed immediate delivery service . . . . this has been achieved by the new use of automation which enables us to cut costs and pass these savings on to you . . . . this has been achieved by more efficient production methods, which reduce processing and material costs which again means savings to you.

Now, you can select from over 19 types of ENGINEERED ECONOMY* IRON CORES which do the job of over 100 types custom-made cores at stock prices. We invite your inquiry.

Also, custom iron cores to your specifications.

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Acme DAGLAS (Dacron-Glass) Insulated Magnet Wire is a smoother, tougher, more flexible magnet wire, therefore a more suitable one for use at Class B or higher temperatures, where a positive inorganic spacing is desired between turns. Handling and winding Acme DAGLAS is easier and more trouble-free than is 100% glass insulated wire . . . therefore faster. In AWG sizes 14 through 30.

POLYVAR—the Acme trade name for polyurethane enamel—introduces a magnet wire that solders directly *without insulation removal!* This improvement greatly reduces processing time as well as lead breakage. POLYVAR has properties fully equal to those of Formvar for wire insulation, plus easy solderability, greater thermal stability, and lower moisture absorption. In AWG sizes 15 through 38. May we send you complete details on Acme DAGLAS and POLYVAR? If convenient, please describe your need.

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ACME WIRE CO.

NEW HAVEN, CONN.

CIRCLE 138 READERS SERVICE CARD

anechoic chambers are given. **Circle 367 on Reader Service Card.**

Dynamic Measuring Instruments. Columbia Research Laboratories, MacDade Blvd. and Bullens Lane, Woodlyn, Pa. A 32-page catalog describes a line of more than 40 accelerometers, high temperature strain gages and associated electric equipment for laboratory and field applications. **Circle 368 on Reader Service Card.**

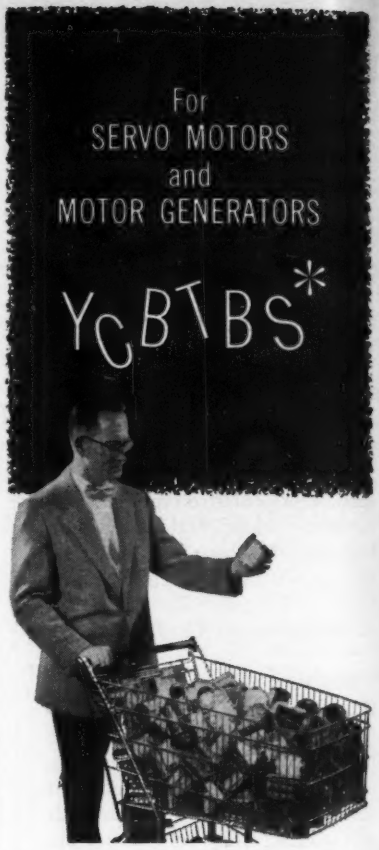
Frequency Meter. Helipot Corp., Newport Beach, Calif. Data sheet 1289 covers complete details of a new, self-contained 400-cycle expanded scale, frequency meter. Included are dimensional drawings of five basic models, product photos that clearly illustrate meter readability, and complete specifications and discussion of circuitry. **Circle 369 on Reader Service Card.**

Products Catalog. General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass., has published the 256-page catalog O containing illustrated descriptions of a wide line of instruments and components. Specifications, prices and ordering information are given. The catalog is thoroughly indexed by title and type number. **Catalog 370 on Reader Service Card.**

TV Tube Aluminizer. Vacuum Equipment Division, F. J. Stokes Corp., 5500 Tabor Road, Philadelphia 20, Pa. The new fully automatic twin-tube tv tube aluminizer, a high-production unit for evaporating an aluminum film onto the screens of black-and-white or color tubes, is described in data sheet No. 590. **Circle 371 on Reader Service Card.**

Time Interval Meter. Electro-Pulse, Inc., 11861 Teale St., Culver City, Calif. Accurate measurements of time interval, periods, and period ratio are applications for the model 7440B time interval meter described in a new two-color catalog sheet. **Circle 372 on Reader Service Card.**

Programmed Current Pulse Generator. Rese Engineering, Inc., 731 Arch St., Philadelphia 6, Pa. A



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Our "supermarket" of rotating components offers a larger variety of high-precision, low-inertia servo motors, rate generators and servo motor generators than any other single source. Bendix units are available in frame sizes 5, 8, 10, 11, 15, 20 and 28; they meet or exceed practically any applicable specification and include both corrosion-resistant and high-temperature models. Volume-production prices. Immediate delivery in many cases. Why not find out about our "supermarket" service!

FEATURING CENTER-TAPPED CONTROL WINDINGS . . .

. . . for use in transistor circuits and for either parallel or series operation. Reduce size and weight of transistorized packages by eliminating coupling transformers. Standard models, or will wind to meet your specific requirements.

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Teterboro, N. J.

Bendix AVIATION CORPORATION

District Offices: Burbank and San Francisco, Calif.; Seattle, Wash.; Dayton, Ohio; and Washington, D. C. Export Sales & Service: Bendix International Division, 205 E. 42nd St., New York 17, N. Y.

CIRCLE 139 READERS SERVICE CARD

four-page folder covers the model 1020 programmed current pulse generator. The equipment described is designed to save countless hours in applications ranging from magnetic core, plane and circuit testing to thin film magnetics research, magnetic drum development, and logic circuit designing and testing. **Circle 373 on Reader Service Card.**

Wide-Range Radiometers. Williamson Development Co., 317 Main St., West Concord, Mass., announces a bulletin on two new wide-range radiometers which permit rapid, direct readings of surface temperatures and environmental radiant temperatures. Applications and specifications are given. **Circle 374 on Reader Service Card.**

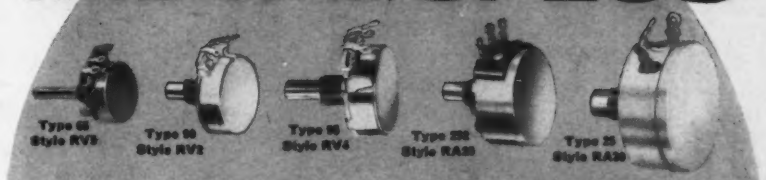
FACILITIES

Custom Molded Plastics. Insulation Manufacturing Co., 11 New York Ave., Brooklyn 16, N. Y., has available a brochure outlining through plant pictures the facilities and "know-how" of the company for the custom molding of thermosetting plastics for industry. **Circle 375 on Reader Service Card.**

Induction Heating Equipment Rental. Induction Heating Corp., 181 Wythe Ave., Brooklyn 11, N. Y. Induction heating equipment, available on rental for as little as $12 per kw output per month, is described in a 4-page brochure. **Circle 376 on Reader Service Card.**

Modern Testing Methods. DITMCO, Inc., 911 Broadway, Kansas City, Mo., has available two new brochures. One, titled "Modern Testing Methods" describes how circuit analyzing equipment is being utilized by various manufacturers to test electrical wiring systems in all phases of production. Another titled "How To Be Sure Your Electrical Wiring Systems Have The Highest Possible Reliability Factor," describes the services offered by the company. **Circle 377 on Reader Service Card.**

CERTIFIED TO LATEST MIL-R-94B 19A SPECS



Newly Developed CTS Military Variable Resistors

Complete line composition and wirewound military variable resistors now in production. Dependable, exceptionally good delivery cycle. Tested and certified to meet latest specs of MIL-R-94B characteristics X and Y, and MIL-R-19A.

Composition controls Styles RV2 (1 watt), RV4 (2 watts) and RV5 (1/2 watt miniaturized) meet latest MIL-R-94B specs. Wirewound controls Styles RA20 (2 watts) and RA30 (4 watts) meet latest MIL-R-19A specs. All are available in a variety of shafts, bushings and resistances. All except Type 65 are available in 2 or 3 section concentric shaft and straight shaft tandem constructions.

Founded 1896

CHICAGO TELEPHONE SUPPLY Corporation

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Specialists in Precision Mass Production of Variable & Fixed Resistors

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CIRCLE 141 READERS SERVICE CARD

Audio Devices Opens Branch

LATEST major electronics plant to begin operation in California's Orange County is the new million dollar Rectifier Division facility (picture) of Audio Devices, Inc. Parent company (headquartered in New York) has long been a leading manufacturer of magnetic recording tape and audio disks. Production of first models late in November '57 marked its launching into the semiconductor field.

By February of this year daily output of the A-750 (400 piv at 750 d-c) model alone was 15,000 units. Exemplifying the division's ambitious production plans is the report by VP-Gen Mgr George J. Eannarino that this figure was upped to 25,000 per day early last month. The total daily production of all models is now 50,000—produced by a million dollars worth of equipment. Electronic components make up 75% of total output.

Two hundred employes and all facilities of the 30,000 sq ft building are devoted to making new types of silicon rectifiers. The five-acre plant site was selected with an eye to future building expansions.

Critical temperature, humidity, and atmospheric requirements for semi-conductor work pointed, the company says, to the Santa Ana location as an optimum site. Dust-free surroundings in the production area are achieved by constant mopping of floors and the use of seven large air conditioning units.

The plant makes its own testing equipment and many of the highly specialized machines needed for its full line of silicon rectifiers (ranging from 0.5 to 200 amperes at various voltages). Each rectifier is tested a minimum of 15 separate times. Rectifiers are encased in all-welded, hermetically sealed, nickel-plated steel housings. With a new design enabling them to be either plugged into a fuse-holder or screwed into the chassis, heat is dissipated and a higher-than-average d-c output rating is obtained. Units are usable to a maximum of 400 volts, piv.

The primary product, A-750, is used in radio, tv, and electronic devices where low cost is essential. It rates 750 milliamperes when screwed into the chassis.

Chief physicist Robert C. Parsons says many other new products are being developed in the research laboratories.

Mandrel Acquires Sequoia Wire

SEQUOIA Wire Co., Redwood City, Calif., manufacturer of wire and cable products for the communications, aircraft and electronics industries, has been acquired by Mandrel Industries, Inc. With this acquisition, Mandrel moved its headquarters from Houston to Redwood City.

Sequoia will be operated as a division of Mandrel. It joins three other divisions: Electric Sorting Machine Co., Grand Rapids, Mich.; Greenleaf Mfg. Co., St. Louis, Mo.; and Electro-Technical Labs, Inc., Houston, Texas.

Company Name Changed

TECHNION Design & Mfg. Co., Inc., of New York City, has changed its name to Duramic Products, Inc.

Headquarters for Duramic Products, Inc., will still be in New York City, although expansion plans are now going forward for additional facilities outside the New York area to meet the demand for special nonmetallic products by the aircraft, electronic, instrument and other industries.

Paskell Joins Delco Radio

FORMER assistant division chief of the Battelle Memorial Institute, Columbus, Ohio, Ernest Paskell has joined the Delco Radio Division semiconductor department in Kokomo, Ind. He will be supervisor of the semiconductor pilot line operations at Delco Radio's north plant.

Council Formed On Long Island

ELECTRONICS firms on Long Island, N. Y., recently formed an Electronics Council to discuss

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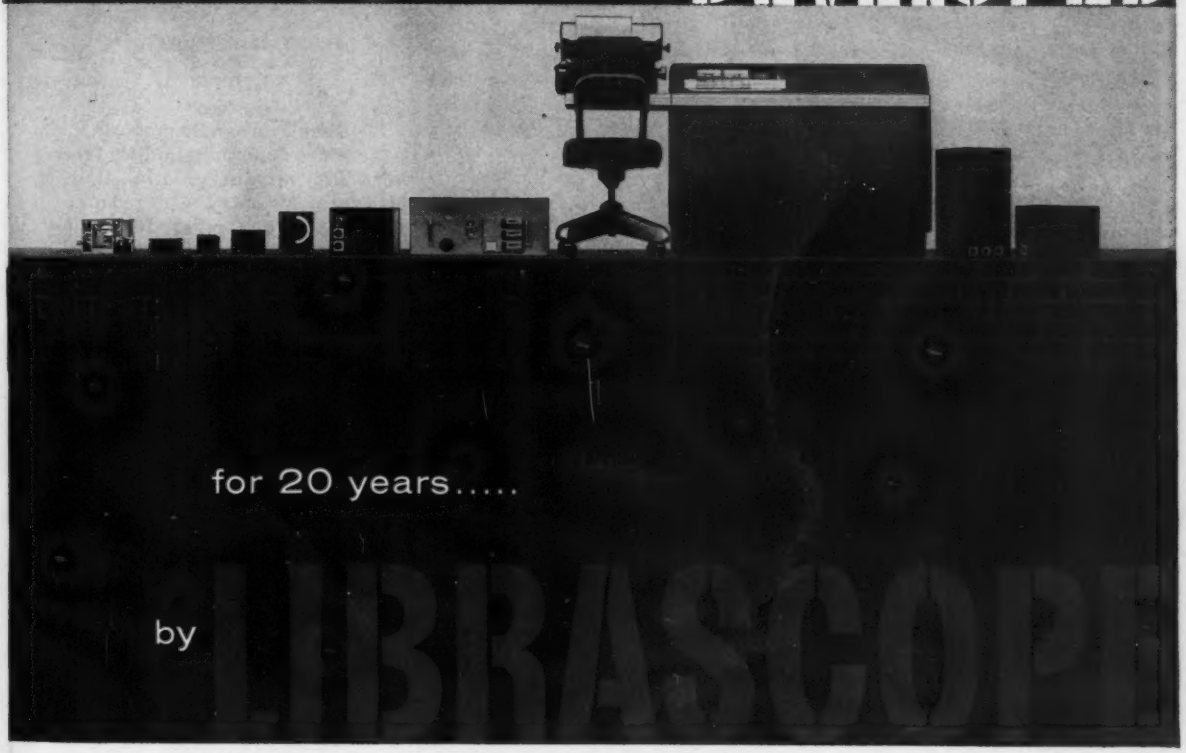
COMPUTERS

DEVELOPED



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SOLUTION TO COMPLEX COMPUTING PROBLEMS are among Librascope's accomplishments as represented by a formidable array of computing equipment. Our selection of the most effective computing solution to meet a problem is based on twenty years of experience gained in the development and manufacture of mechanical, electrical, electronic and magnetic computing devices. Computers for both military and commercial purposes are developed and manufactured by Librascope. Inquiries on computing control problems are welcome.

Engineers capable of significant contributions are invited to write Glen Seltzer, Employment Manager.

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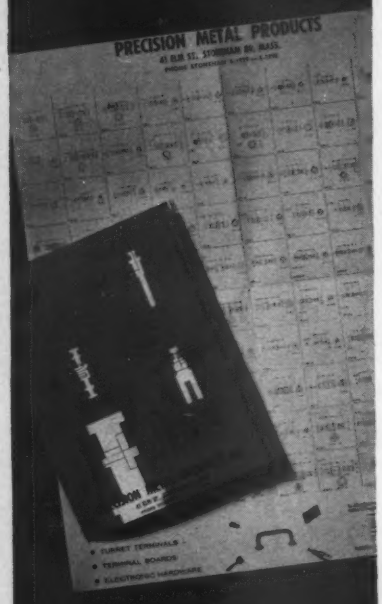

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Free PMP CATALOG and REFERENCE CHART

Precision Metal Products new 40 page catalog provides you with one convenient source of information on 96 different in-stock terminal lugs. It's the most complete line in the industry. Whatever your lug needs, you'll find that PMP can give you immediate delivery.
The PMP catalog and price list has complete information on sizes, dimensions and prices. Also included is a wall chart giving complete engineering details on all standard types for easy reference by purchasing agents, draftsmen and engineers.

Write for your free catalog and reference chart today!

PRECISION METAL PRODUCTS COMPANY
41 Elm Street, Stoneham, Mass.

CIRCLE 142 READERS SERVICE CARD

common aims and problems. The council, which had 14 members at its organizational meeting, was set up under the auspices of The Long Island Association, the regional chamber of commerce.

All firms in the council are members of the LIA, which will provide secretarial and staff services. Elston H. Swanson (pictured on p 170), president of Instruments for Industry, Inc., of Mineola, has been chosen council chairman.

As its first study, the council has undertaken a survey of the wages and salaries paid in the electronics industry on Long Island. Appointed to a committee to carry out the survey were William Sylvester of Acoustica Associates, Miss Frances Kaplan of General Transistor, C. Corbin of HiTemp Wires and John Hicks of Instruments for Industry.

Make Cameron Plant Manager

PROMOTION of Frank H. Cameron (picture) to plant manager is announced by Clarostat Mfg. Co., Inc., Dover, N. H. Cameron joined Clarostat in March 1957 as chief industrial engineer, and in July that year was made acting plant manager.

Western Firm Fills Key Jobs

PACIFIC Automation Products, Inc., Glendale, Calif., missile systems engineers and electronic cable manu-

96 STANDARD VARIATIONS

New Y DIGITAL READ-OUT COUNTERS by DURANT

Design engineers can now select one or more standard units from a range of 96 Instrument Counters, having the same type of frame and configuration.

1½ WIDTH UNIT WHEEL
5-Y-8822 WITH SINGLE WIDTH UNIT WHEEL
SINGLE BANK SERIES
(Right or Left Drive)
2 to 7 Figures
DOUBLE WIDTH UNIT WHEEL

Here is a family group that provides uniformity in digital recording to satisfy nearly all design requirements . . . on radar equipment, navigation instruments, computers, missile tracking devices, and gauging instruments.

They are compact, average weight only 2 ounces, have easy to read figures, white on black . . . speeds to 2500 RPM. Available in single or dual bank style, in 2 to 7 figures capacity . . . three styles of unit wheel configuration.

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CIRCLE 143 READERS SERVICE CARD

facturers, announce key personnel appointments. Frank La Fetra, with headquarters at the firm's Glendale office, is named senior liaison engineer, responsible for the direction of sales engineering activities for the Western states. Robert R. Knerl is appointed supervisor of bids, proposals, statistical records, and inside customer contacts. He is assisted by Robert Anspach and Burt Johnson.

Howard F. Somer is director of technical publications, exhibits, and advertising, and is responsible for release of technical information. Robert J. Montgomery is supervisor of order service, a sales department function which monitors production and delivery schedules.

Miniaturization Award Presented

THE FIRST annual Miniaturization Award was recently presented at the Waldorf-Astoria, in New York, to the Diamond Ordnance Fuze Laboratories, U.S. Department of the Army. Horace D. Gilbert, chairman, miniaturization awards committee, and president of Miniature Precision Bearings, Inc., Keene, N. H., is pictured at left presenting the award to DOFL commanding officer.

The award has been established to recognize the individual organization or achievement which has done the most to further the con-

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The new Millivac MV-57A DC precision VTVM has better than 1/4% accuracy and is designed especially for those who find ordinary 2 or 3% VTVMs not accurate enough. It costs less; is more sensitive than most digital voltmeters.

TYPE MV-57A
$790
1/4% ACCURACY
Measures
100 uV to 1 kV

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14 - $3\frac{13}{32}$x3
23 - $4\frac{5}{8}$x$4\frac{3}{8}$

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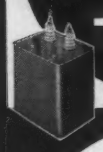

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cept of miniaturization. Sponsored by Miniature Precision Bearings, Inc., it is administered by an independent committee composed of representatives from industry, education, the military, and government.

Diamond Ordnance Fuze Laboratories was selected to receive the award for its work in developing a new concept to miniaturize electronic parts and subassemblies through the use of photolithographic processes and printing techniques.

CBS Labs Fills Key Post

APPOINTMENT of John M. Hollywood (picture) as scientific aide to the president of CBS Laboratories, is announced by Peter C. Goldmark, president. Hollywood first joined CBS Laboratories in 1936.

During the first half of World War II he participated in the CBS Laboratories' electronic countermeasures work for the Armed Forces. He moved to England where he continued on these projects in the American countermeasures laboratory operating for the 8th Air Force, under the direction of Peter Goldmark.

Raytheon Shifts Top Structure

THREE-MAN Office of the President is created by Raytheon Manufacturing Company in reorganization of top management structure.

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Adams in general corporate management is Percy L. Spencer as senior vice-president (ELECTRONICS, Feb. 7, p50) and Harold S. Geneen as executive vice president.

Reorganization comes 10 years after C. F. Adams became president of Raytheon. In 1948, company had 5,000 employees, annual sales of $54 million, government backlog of $34 million and plants totaling one million square feet of floor space. Raytheon now employs 28,000 in plants and laboratories in Massachusetts, New Hampshire, Tennessee, California and New Mexico, annual sales of $225 million, government backlog of $250 million plus, and plants totaling four million square feet of space.

News of Reps

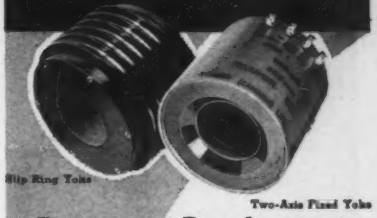
Shamp Scientific Supply Co. will provide Control Electronics Co., Inc., Huntington Station, N. Y., sales coverage in connection with both government and industrial activities in Washington, D. C., and Baltimore.

The electronics division of Elgin National Watch Co. appoints **Southern Sales Co.**, Angola, Ind., as sales reps handling the company's Advance relay line in northern Indiana.

CDB Enterprises will sell the complete line of microwave test equipment and components for Polytechnic Research & Development Co., Inc., Brooklyn, N. Y., in the territories of northern New Jersey and southern New York. **Engineering Associates** will handle the PRD line in Delaware, Maryland, Washington, D. C., Virginia and North Carolina.

Formation of **Eastern Associates, Inc.**, as representatives of manufacturers of electronic instruments is announced. The firm has located sales offices in Baltimore, Md., and in Abington, Pa. The area covered for their principals includes eastern Pennsylvania, southern New Jersey, Delaware, Maryland, Washington, D. C., and Virginia.

PRECISION DEFLECTION WITH COSSOR YOKES



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Normal characteristics of yokes for 1-1/2 in. neck tubes are:

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Complete encapsulation in epoxy (stycast) or silicone resins is standard for all Cossor deflection yokes, and is done with special moulding tools ensuring accurate alignment of the yoke axis. When slip rings are added, solid silver rings are mounted in encapsulating resin. The finished slip ring yoke is precision turned to centre bore, and can include bearing mounting surfaces with dimensional tolerances approaching those associable with high quality metal parts.

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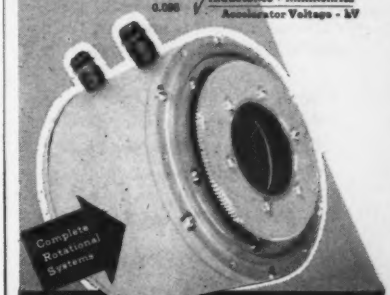

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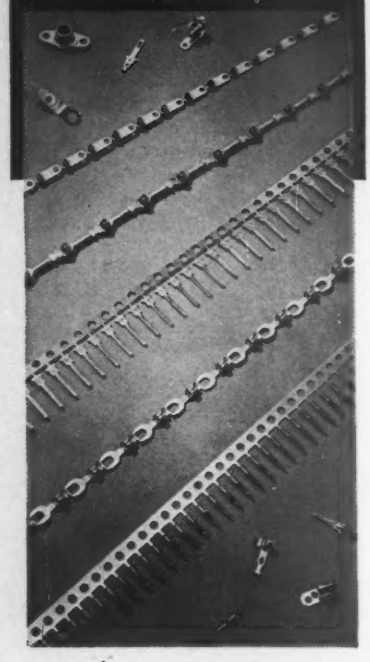

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NEW BOOKS

Handbook on Noise Control

EDITED BY CYRIL M. HARRIS
McGraw-Hill Book Co., New York, 1957, 1,050 p, $16.50.

THIS handbook was written by a battalion of 46 experts, describing the various manifestations of noise and its control, both physical and legal.

After a preface in which the leitmotiv is pronounced ("people do not like noise") the editor introduces the reader to the subject and gives a helpful list of terms used in the volume from "absorption coefficient" to "white noise." This is followed by two chapters on the physical properties of noise and the propagation of sound in the open air.

Hearing Fundamentals—In the next part of the book, the reader is familiarized with the fundamentals of the hearing mechanism, the loudness of sounds and the various scales related to hearing: namely, the loudness level scale (unit: phon), the loudness scale (unit: sone) and the pitch scale (unit: mel).

Three chapters are devoted to audiometry, hearing loss and ear protection. The important questions of the effects of noise on speech and human behavior and the reaction of man to vibration are treated in detail.

Four chapters are devoted to various physical aspects of vibration: vibration control, vibration isolation, vibration damping and vibration measurement. Other chapters are concerned with the techniques of and the instruments for noise measurements with acoustic materials, control of solid-borne noise (with detailed transmission loss data for many types of partitions) and systems considerations.

Noise Generators—Much of the remainder of the handbook is devoted to specific noise generators and their properties. Among them we recognize many an old noisy "friend": gears, bearings, fans, refrigerators, air conditioners, transformers, chokes, automobiles (including buses and motorcycles), railroads, aircraft, electric motors

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and generators and water, steam, heating and ventilating systems.

The concluding chapters outline the political and judicial aspects of noise. There are articles on community reaction to noise, legal aspects of aircraft noise, legal liability for the loss of hearing, noise control requirements in building codes and antinoise ordinances (including a model ordinance with fines up to $25 and/or 10 days imprisonment).

The handbook makes a well ordered and well indexed appearance and seems to be quite comprehensive. There are 1,300 references of which 1,206 are to English language publications.

Among the few omissions noted by this reviewer is that of a treatment of some of the properties of noises resulting from the simplest stochastic processes. Here we think of the relation between power spectrum, auto-correlation function and the number of axis-crossings, various amplitude distributions and envelope properties of band-limited noise. It is felt that a chapter devoted to the mathematical properties of noise would constitute a valuable supplement to the introductory part of the handbook.

The handbook can be, on the whole, highly recommended. In view of the practical importance of the subject, it is hoped that it will find its way onto the desks of a large number of producers of "noisy matter."—M. R. SCHROEDER, *Bell Telephone Lab., Murray Hill, N. J.*

Elektromagnetische Wellenleiter Und Hohlräume (Electromagnetic Waveguides and Cavity Resonators)

BY GEORG GOUBAU

Wissenschaftliche Verlagsgesellschaft m.b.H. Stuttgart, Germany, 1955, 460 p.

THIS German volume presents a fundamental theoretical treatment of waveguides and resonators. The mathematical description is both elegant and complete. In contrast to many American books on the same subject, there is almost no engineering discussion. The emphasis is on the formal treatment of

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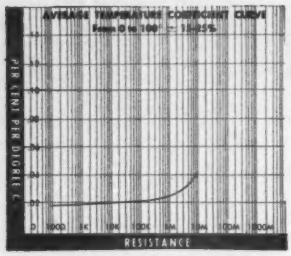
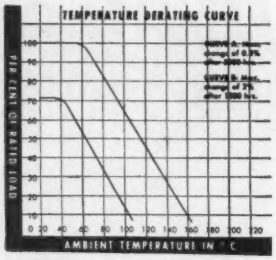


Temperature coefficient characteristics for ALPT—1 watt resistor



Derating curve for ALPT—1 watt resistor

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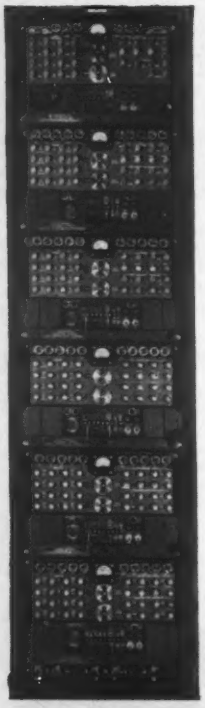

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both the field theory description and the equivalent network description. This book will be most useful to the theoretician and of limited usefulness to the design engineer or the user of waveguide apparatus.

Dated Material—It is to be regretted that the material presented here is limited to that completed by Dr. Goubau in 1947 shortly before his departure for the United States. His latest work on dielectric covered lines is therefore not treated at all. Despite this the reader will probably find interesting differences of approach to some of the standard problems. In particular, the discussion of the driven resonator—(Chapter II p. 131 ff) introducing the concept of primary fields associated with the coupling system and secondary fields associated with the resonator appears to be quite different from most treatments of this problem.

The first chapter, by Richard Honerjäger, gives a thorough statement of the Maxwell theory as applicable to straight cylindrical waveguides of arbitrary cross section. The general characteristics of the various modes are derived and reflections at dielectric and metallic surfaces are described. Applications are made to rectangular, circular, coaxial and sectoral cross sections.

Cavity Resonators—The second chapter, by Rolf Muller, presents the theory of cavity resonators. The normal mode solutions for a perfectly conducting cavity are derived. Following this, the perturbed resonator is treated, including perturbations of the dielectric volume and perturbations of the walls. The latter include finite conductivity, distortion and tuners. The excitation of resonators is described in terms of driving electric and magnetic moments and the concept of primary and secondary fields is introduced and exploited. Applications of the general theory are made to cylindrical, rectangular, reentrant shapes and others.

The third chapter, by Georg Goubau, treats the theory of transmission-line-coupled systems. The equivalent network for waveguides is set up, as are the two-terminal equivalents for discontinuities. Among the elements discussed are

dielectric windows, metallic irises, stub tuners and dielectric transformers. By the use of the transmission line impedance chart, reflection coefficients and their transformations are described and calculated. Waveguide filters are described and several examples given.

Coupled Resonators—The last chapter, also by Dr. Goubau, presents the theory of coupled resonator systems. Again exploiting the concept of primary and secondary fields, both electric and magnetic coupling systems are analyzed. Specific calculations are made for loop coupling and other coupling elements between a transmission line and a cavity resonator. The coupling between two transmission lines leading to direction couplers is treated briefly as is the periodic line with bandpass characteristics.

A number of mathematical appendices and several tables of equivalent circuit parameters for common waveguide configurations complete this interesting volume.—M. Ettenberg, *Eng. Dept. Head, T.W.T. Res. and Dev., Sperry Gyroscope Co., Div. of Sperry Rand Corp., Great Neck, L. I.*

Handbook of Electronic Measurements—2 Vol.

Edited By Moe Wind

Polytechnic Institute of Brooklyn, Microwave Research Institute, Brooklyn 1, N. Y., 1956, 950 p, $15.00.

These last years have ushered in such a large profusion of new and important developments in the field of electrical engineering that most engineers have been driven through necessity to embrace and concentrate their activities in an evermore restricted field. Thus we have microwave engineers, computer engineers, audio engineers and so on. For this reason, among others, a handbook which brings together and provides rapid access to complete, and concise and scholarly presented engineering information and which crosses the boundaries of fields of specialization is certainly a much welcomed addition

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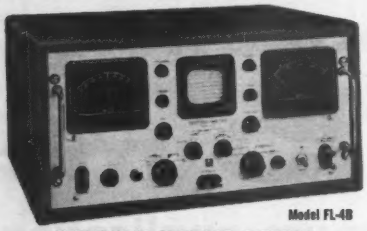

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to contemporary engineering literature.

Treatise Format—This work is not a handbook in the conventional sense in that it is not a collection of tables and formulas which is often ordinarily of value only to one reasonably well conversant with the field under review. It is rather a series of treatises ranging through the entire field of electrical measurements. The underlying physical and engineering principles basic to an understanding of the measurement methods presented are discussed and analyzed first before the particular measurement techniques are described.

The theoretical discussions are, in many instances, quite extended and complete. For the most part, the work reads like a textbook, at a fairly sophisticated level to be sure, rather than a handbook.

D-C to Microwave Range—The frequency range encompassed in each of the separate articles ranges from d-c through the microwave region, while the type of measurement contemplated ranges from those which yield rapid order-of-magnitude estimates to those which are capable of yielding the highest accuracy and precision.

While the work is slanted in the direction of discussing the type of measurement which will be of greatest interest to the engineer working in the field of electronics, nevertheless it is not really confined to the field of electronics. Of 18 chapters, eight are concerned with the basic concepts and parameters in terms of which engineers have learned to characterize all circuitry, electronic or not.

The first chapter departs from the pattern set by the remaining chapters in that it does not discuss specific measurement techniques. Rather it serves to present a brief, but fairly complete, review of the fundamentals of electromagnetic theory and provides a very perceptive insight into the nature of the approximations involved which permit one to make the transition from field theory to circuit theory. This chapter also defines units and standards and gives a short historical introduction into the prob-

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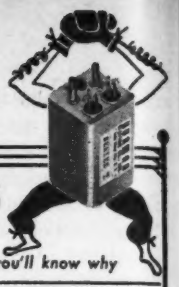

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lem of electromagnetic measurements.

Voltage and Current—The second chapter deals with the measurement of voltage and current and describes the principles of operation, sources of error and limitations of the wide range of instruments, electronic or nonelectronic, available for the purpose.

In chapter three, which deals with the measurement of power, there is to be found a rather extensive treatment of power measurement in the microwave region. Calorimetric and bolometric methods are analyzed as well as a number of other methods which are less familiar. Chapter four is concerned with the measurement of impedance and circuit elements with some emphasis on impedance and distributed constants at microwave frequencies. Here we find a very clear and cogent presentation of the circuit theory which is necessary to understand the techniques of measurement employed.

Frequency and Wavelength—Chapter five deals with the measurement of frequency and wavelength. After a brief discussion of frequency standards there are described, among others, oscillographic, bridge, stroboscopic and heterodyne methods and finally methods appropriate at microwave frequencies.

The pattern of thoroughness, excellent organization and clarity set in these early chapters is consistently maintained in all the succeeding chapters. To convey an idea of the contents of what follows we may note the chapter headings which are the following: Measurement of Time Interval, Measurement of Phase, Measurement of Field Intensity and Radiation Measurement of Bandwidth, Gain, Measurement of Noise Figure, Measurement of Transient Response, Measurement of Distortion, Oscillographic Observation of Waveform, Stability Measurements, Measurement of Modulation, Spectrum Analysis, Attenuation and its Measurement.

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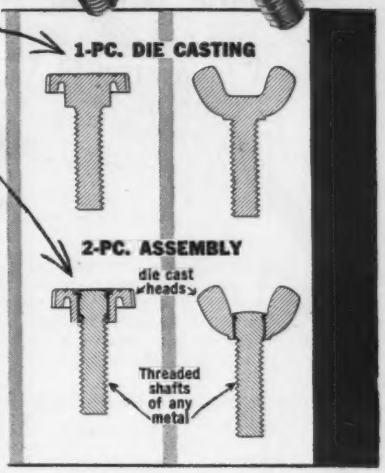

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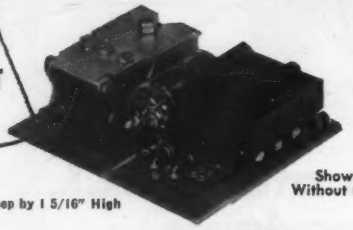

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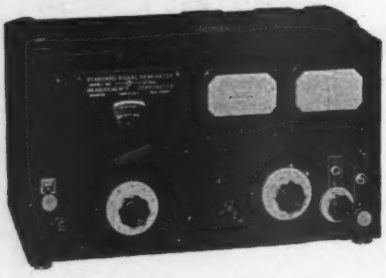

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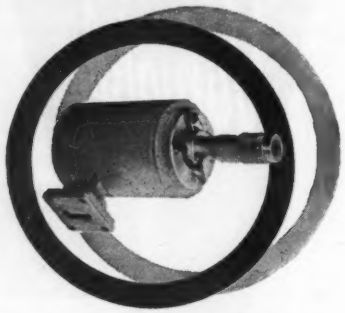
D-B broad band gas-filled cavity wavemeters



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ried out very creditably indeed what must certainly have been a formidable undertaking. The quality of the individual treatises which comprise the whole are uniformly excellent from the point of view of organization and clarity of presentation as well as from the point of view of technical correctness. The work is about as complete as it may reasonably be expected to be consistent with the total number of pages allotted to it.

In a goodly number of instances one finds descriptions of commercially available equipment which is available for carrying out the measurements described.

Probably on account of limitations of space the number of such references to commercial equipment and the detail of description had necessarily to be restricted On the other hand each article in the work has appended to it a very extensive and complete bibliography which in very large measure makes up for this minor limitation. Altogether, this reviewer feels that these volumes are an excellent contribution to engineering literature and make an eminently worthwhile addition to any electrical engineering library.—HERBERT TAUB, *Dept. of Elec. Eng., The City College, New York, N. Y.*

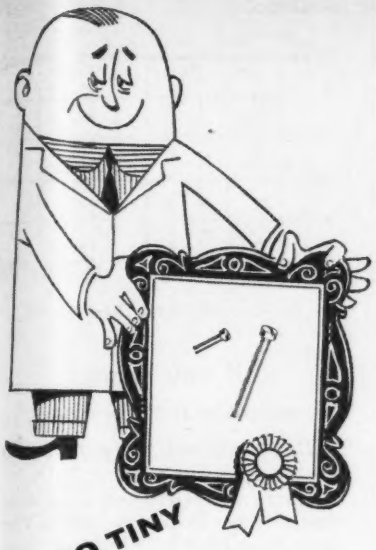
Electronic Analog Computers

BY GRANINO A. KORN and THERESA M. KORN

McGraw-Hill Book Co, Inc., New York, 1956, 452 p, $7.50.

AT the time the first edition of this book was published, this reviewer had considerable disappointment because the book had purported to be a text book. Yet the reader's reaction was that considerable background was required in order to benefit from its reading and therefore the book was more a reference volume than a text.

By and large, the second edition has overcome these objections. Contents—The book contains first an introduction to analog computers. This is a compact summary valid for design of special purpose



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00	90	0.047	0.0403	0.0326	0.01111	0.00721
0	80	060	.0519	.0438	.01250	.00812
1	72	.073	0640	.0550	.01389	.00902
2	56	086	.0744	.0628	.01786	.01160
3	48	.099	.0855	.0719	.02083	.01353
4	40	112	.0958	.0795	.02500	.01624

SIZE	Head Diam.	Height of Head	Depth of Slot	Width of Slot	Tap Drill	Body Drill
000	.056	.031	.014	012	#71 (.026)	#63 (.037)
00	.068	.038	.014	.023	#65 (.035)	#55 (.052)
0	.090	.050	.022	.025	3/64 (.047)	#51 (.067)
1	.111	.062	.024	.027	#53 (.059)	#47 (.078)
2	132	.073	.029	.030	#50 (.070)	#42 (.093)
3	.153	.084	.035	.032	#47 (.078)	#37 (.104)
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analog computers as well as for the utilization of complete analog computer installations. It is slightly expanded over the first edition and as a result has added sufficient explanations for a neophyte.

Chapters 2 and 3 concern the utilization of complete systems. These chapters still leave the impression of requiring substantial experience or familiarization with equipments to appreciate the text.

Chapters 4, 5 and 6, as a result of reorganization and expansion, provide excellent design and reference information. From information in these chapters, an electronics engineer will be able to design his own computer circuits and will also be able to understand the problems and limitations of analog computer circuitry.

In particular, the sections on multiplication and division, which offer the most difficulty in design phases, are well covered and easily comprehended. Chapter 7 on auxiliary circuits and Chapter 8 on design of complete d-c analog-computer installations are brought up to date and contain information which is useful in a reference fashion but not necessary in a text book.

The tables of special computer setups in the first appendix will be of substantial value to equipment designers and users and is a valuable addition.

Summary—All in all, the second edition of "Electronic Analog Computers" provides the necessary information to make a useful text book for graduate engineers and for users of complete analog systems. It is regretted that the book confines itself to d-c analog computers since a-c computation has developed rapidly in recent years and offers substantial advantages in many cases. While the first edition of this book was considered as a good reference but not a good text, the second edition has overcome most of the deficiencies and is now considered an adequate text book for the engineer desiring to undertake analog computer design. —M. Lloyd Bond, *Plant Manager, Avion Div.-Alexandria, ACF Industries, Inc., Alexandria, Va.*

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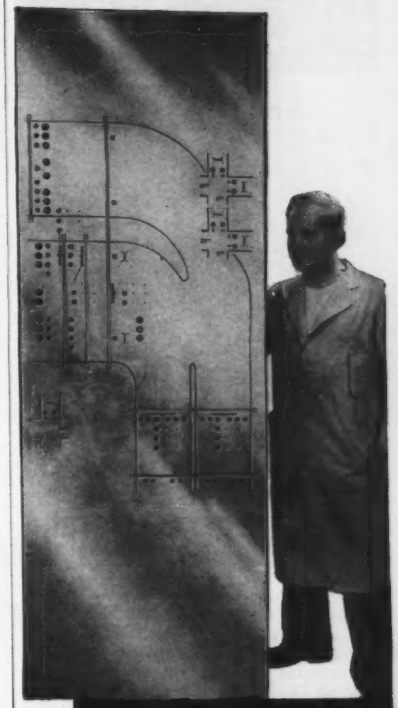

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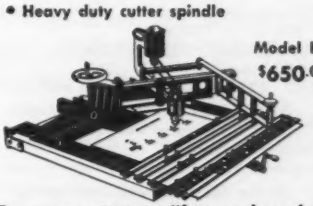

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COMMENT

Wireless Microphone

In ("Wireless Microphone Uses F-M Modulation," Jan. 3, p 54) there is a description of an inductive microphone pickup using a transistorized transmitter operating on 150 kc.

This appears to be an answer to our problem in a new church we are constructing, and we would like to construct or buy such a system so that the pastor will have freedom of movement about the Chancel during the sermon. Our services require voice reinforcement and also they are broadcast.

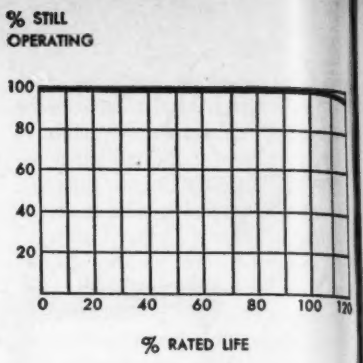
RONALD J. ANDERSON
ANDERSON RADIO
BAY CITY, MICH.

. . . Several comments based on experience with the microphone since the ELECTRONICS article was prepared may be of interest.

To begin with, the instrument was designed to comply with the original FCC regulations limiting the permissible radiation from low-power devices. More recently, the FCC has relaxed these regulations to permit greater fields in certain restricted ranges of the radio spectrum, in particular in the ranges 10-490 kc and 510-1,600 kc. These revisions may permit a more satisfactory design without increase of transmitter power consumption.

The equipment has been in use here for about seven months. Several design changes would be desirable if the project were to be done over. A more conventional receiver would be preferable. The present one is a superheterodyne; harmonics from the 50-kc i-f amplifier are present at the receiver input and cause low-level a-f heterodynes in the output. The amplitude of this interference is not large and can be avoided by careful tuning. It could be eliminated completely by substituting two or three stages of amplification directly at the transmitter carrier frequency, followed by a limiter and conventional tuned frequency discriminator.

The transmitter itself is quite satisfactory. We have had some



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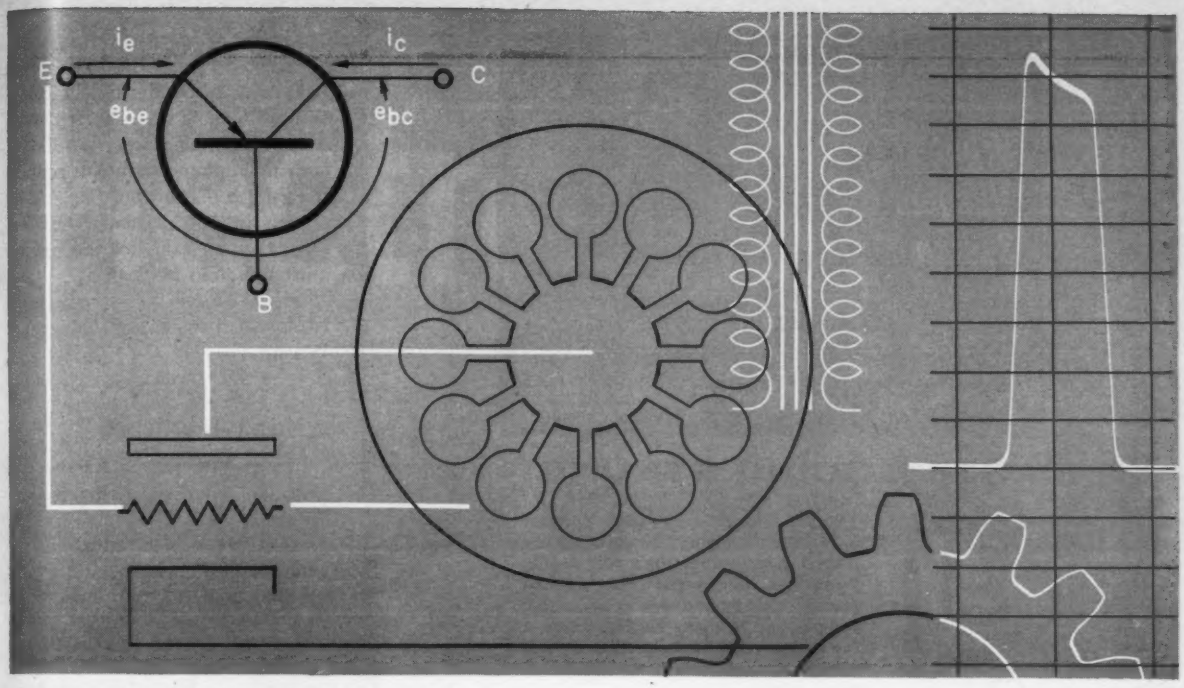

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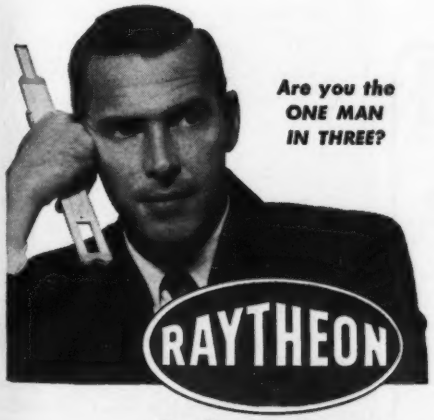

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difficulty with overloading at the modulator when the transmitter is used by loud talkers. A 3,300-ohm resistor shunted across the 30,000-ohm microphone terminals reduces the gain so that overloading seldom occurs; in any particular environment the best value for this resistor must be found by trial. . . .

G. Franklin Montgomery
National Bureau of Standards
Washington, D. C.

Cathode-Follower Gain

Referring to the circuit diagram (Fig. 1 in "Cathode Follower Gain Approaches Unity," Jan. 3, p 94), considerable simplification can be achieved by the use of standard differential computer amplifier techniques.

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We commend this amplifier to the electronic designer as being a practical solution to this ubiquitous problem.

Daniel H. Sheingold
G. A. Philbrick Researchers
Boston, Mass.

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Josiah S. Carberry
Providence, R. I.